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FIFTY YEARS OF PROGRESS IN ROENTGENOLOGY OF THE CHEST*

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IN THE belief that it is of more interest to record dynamic processes than to compile a catalogue of dates and events, we have in this review attempted to indicate some of the forces that have guided the course of chest roentgenology over the past fifty years. For convenience we have considered the progress of the specialty in terms of several rather arbitrarily defined periods corresponding roughly to the eras in which various major influences waxed and waned. We have dwelt perhaps overlong on the achievements of early years, partly because they are less familiar to radiologists of today than are the accomplishments of the past two decades, and partly because we lack the perspective to evaluate more recent contributions. Many early proposals have been cited as evidence of the vision of the pioneers, but no attempt has been made to assess conflicting claims to priority in various technical developments.

This review should properly begin with the founding of THE AMERICAN QUARTERLY OF ROENTGENOLOGY in 1906, but many of the seeds for subsequent developments had already been sown at that time, and we have, therefore, turned back to the first decade after Roentgen's announcement of "A New Kind of Rays" to begin our review of the progress of chest roentgenology.

1895–1905

This initial era was one of tumultuous activity. So swiftly did one development follow another, that within the first ten years, the pioneers had envisaged virtually every major technical advance of the succeeding fifty years.

Generators during the period progressed from small battery powered coils to static machines and by 1905, to large coils operated from power lines with electrolytic interrupters. In tube design, the platinum target bonded to copper for heat conduction, and a regulator to control the vacuum of the "cranky" gas tube became realities; while the line focus principle was discussed (Rollins, 1904); an oil immersion tube (Trowbridge, 1896) and a hot cathode gas tube (Wehnelt and Trenkle, 1905) were built; and the rotating anode proposed (R. W. Wood, 1897). Edison demonstrated

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the superiority of calcium tungstate over barium platino-cyanide for making a fluorescent screen (March, 1896), and his friend Pupin demonstrated the usefulness of such a screen for intensifying the "skiagraphic" image (February, 1896). Diaphragms (Burry, 1896) and cones (Albers-Schönberg, 1902) to control scatter were introduced, and sensitized film and bromide paper (1896) were produced, though the glass plate was still the standard recording medium in 1905.

A variety of special techniques were developed or proposed. Stereoscopy (Elihu Thompson, 1896) became the most useful of these clinically. Hickey (1904) anticipated the development of bronchography as well as angiography by recording the opacified tracheobronchial tree and pulmonary vessels of a cadaver to elucidate the significance of the shadows at the "lung roots," and just four months after the first motion picture was shown in London, Macintyre demonstrated the first attempts at cineroentgenography (on Ladies' Night at the Royal Academy, June, 1897). Orthodiagraphy was introduced (Moritz, 1902) and the principle of teleroentgenography (Köhler, 1905) was discussed though tube limitations prevented its general application.

Various explanations for the tremendous activity and progress of the period may be proposed. Fundamental perhaps was that enthusiasm which is created by any new medium. The discovery of the roentgen rays, however, more than that of any other physical phenomenon caught and held the fancy of the public and the world of science alike. Men of many disciplines were attracted by it, and roentgenology's early development resulted from the combined efforts of photographers, physicists, engineers, inventors, and clinicians. Those gripped with the enthusiasm knew none of the inhibitions imposed later by concepts of radiation safety, and often with tragic effects in later years, they devoted themselves to the development of Roentgen's discovery.

The application of the ray to clinical medicine was immediately apparent and Rosenfeld may have made the first published chest plate in Breslau in 1897. By 1901, Francis Williams was able to publish his brilliant book, *The Roentgen Rays in Medicine and Surgery*, which was largely devoted to his fluoroscopic observations of the chest. Pfahler, like Williams, described the findings in many intrathoracic lesions and laid the foundation of good clinical roentgenology by urging that "a careful physical examination should precede the Roentgen examination, not because it will modify the shadows, but because it will enable the radiologist to interpret those present."

Clinically, fluoroscopy had been used almost exclusively in the first half of the decade, but reports of radiation dermatitis and finally the first death attributable to the effects of radiation (Dally, 1904) emphasized the hazards of the technique, and by 1905, it was almost abandoned. Contributing to the decline of fluoroscopy was the steadily improving quality of the "skiagram." "Instantaneous skiagraphy" was introduced, and in 1905, Rieder and Rosenthal exhibited a chest exposure without respiratory movement. Though Burdick felt that "instantaneous" roentgenography would not become popular because of the hazard to tubes (which at twenty dollars apiece were not to be sacrificed lightly), the technique rapidly gained favor.

At the close of this era, clinical roentgenology was still more art than science and had its disquieting moments judging from repeated reports of roentgen tube explosions. Pfahler's report of demonstrating "tubercles the size of a pin head" suggests, however, that it was possible to obtain plates of remarkable quality despite the imperfections of the available equipment.

1906–1913

The next period of development saw equally remarkable technical and clinical progress, but is even more significant, perhaps, as the period in which radiology was

established as an organized specialty of clinical medicine. The Roentgen Society of the United States had been organized in 1900, having had as members physicians, dentists, electrotherapists, and physicists. However, when Preston M. Hickey launched THE AMERICAN QUARTERLY OF ROENTGENOLOGY as the Society's official organ in 1906, the direction of the Society, by then the American Roentgen Ray Society, was firmly in the hands of the physician-radiologist. Under this leadership, interest in radiology increased so rapidly that the QUARTERLY soon proved inadequate and gave way to THE AMERICAN JOURNAL OF ROENTGENOLOGY, a monthly publication, in 1913.

Technical progress during this period resulted in the introduction of the Snook interrupterless transformer in 1907. Capable of generating roentgen rays at 100 kv. peak and at currents up to 100 ma. (in excess of the capacity of existing tubes), this was the first reliable transformer. About 1909, the autotransformer was introduced, and in 1912, Waite's vertical fluoroscope, shielded to protect the operator, became generally available. This unit did much to encourage the profession's resurgent interest in fluoroscopy.

The climax of the era, however, came with Coolidge's announcement on December 27, 1913, of a successful hot cathode vacuum tube. To say that, like other scientific developments, the Coolidge tube represented the culmination of years of work on the part of many investigators is not to detract from Coolidge's genius in having perfected a stable high output roentgen tube. His invention remains today the most important technical contribution to diagnostic roentgenology.

Though these technical advances did not become generally available at once, clinical roentgenology advanced rapidly, and this era was to mark the beginning of the conquest of tuberculosis. The chest plate became an accepted medium for the detection of intrathoracic disease, and by 1912, clinicians recognized it as superior to physical examination alone. Sanatoria began the roentgen examination of all admitted patients, and Cole (1910) proclaimed that with the roentgen ray as an agent "the diagnosis of incipient tuberculosis is solved." Others were enthusiastic but more guarded in their conclusions, while Hickey wisely cautioned that not "all the plates we make are absolutely pathognomonic of the different lesions of the chest" and urged conservatism "lest we allow our enthusiasm to lead us somewhat astray and we draw conclusions that are not always justified."

1914–1919

Even before the United States became directly involved in the conflict, the first World War profoundly affected the development of roentgenology in this country, and the outbreak of hostilities signalled the beginning of a new era. Its earliest effect was to stimulate the development of American products. Eastman, unable to obtain glass plates from Belgium, brought out a single emulsion roentgen film on a cellulose nitrate base in 1914, and double emulsion film followed in 1918. Threkeld-Edwards had produced the first American screen in 1912, and the Snook lagless screen, a distinct improvement in screen design pioneered by Carl Patterson, followed in 1913. The demand for domestic screens finally prompted Patterson to begin manufacturing his own product in 1916. This new venture was to be of great significance in the development of chest roentgenography for Patterson's name was to become synonymous with high quality screens.

With the entry of the United States, the War's effect became even more profound. Roentgenology had to be practiced under adverse circumstances in the field, and the need for special equipment became apparent. The radiator tube, developed in 1918, was followed shortly by self-rectification, and led to the Coolidge portable unit which was afterwards modified for bedside use.

Though military demands turned the

clinical interests of the profession to the localization of foreign bodies, interest in tuberculosis did not decline. Crane, Cole, and Dunham carried on their work of recording the characteristic roentgenographic findings in pulmonary disease with especial interest in tuberculosis. Dunham particularly was active in correlating the roentgenographic with the pathologic findings. As a result, during this period roentgenographic findings were analyzed and roentgenographic criteria for the diagnosis of tuberculosis were evolved. In 1916, the Trudeau group proposed classifying tuberculosis in terms of the roentgenographic findings, and in 1917, the first edition of *Diagnostic Standards and Classification of Tuberculosis* was published. In the course of this process of evaluating the diagnostic criteria for tuberculosis, other pulmonary lesions emerged as discrete entities having somewhat characteristic roentgenographic findings. Among these were the pneumoconioses. Silicosis was already a compensable disease in some countries (South Africa), and the establishment of objective roentgenographic criteria for its diagnosis was to be of utmost importance. Interestingly enough, however, silicosis was not then compensable in this country and the researches of Pancoast, which began at this time, appear to have been motivated largely by scientific interest.

The fluoroscope had always been favored for the study of the heart and great vessels and with the decline of fluoroscopy between 1900 and 1912, interest in the diagnosis of cardiovascular disease was limited, though excellent work, like that of Baetjer on thoracic aneurysms (1905), appeared from time to time. During the War period, interest was renewed, and the roentgenologic study of these organs was facilitated by the availability of high output Coolidge tubes which made Köhler's old method of teleroentgenography feasible, and also by the availability of relatively safe fluoroscopes which permitted the popularization of orthodiagraphy. Crane and Wessler, among many others, contributed to the growing knowledge of the roentgenologic findings in various forms of cardiac disease during this period.

1920–1925

The early 20's saw Sante begin his classic studies of pneumonia, lung abscess, and massive collapse. His efforts stimulated considerable interest in this field, but perhaps the greatest single influence on the development of chest roentgenology during the post-war period was Chevalier Jackson's popularization of the bronchoscope. The bronchologist not only played a vital role in the development of bronchography, but his intensive study of endobronchial foreign bodies led to an appreciation of the roentgenologic manifestations of deranged pulmonary dynamics, a subject on which both Jackson and Manges published extensively.

Since 1904, the detection of bronchiectasis had been of interest to radiologists but even in 1918, the roentgenographic criteria for its diagnosis were not specific—the diagnosis was often highly uncertain. A better diagnostic technique was needed, and Jackson, who had for some years been marking tumors with bismuth for roentgen ray localization, conceived the idea of insufflating the tracheobronchial tree with bismuth powder. In 1918, he employed this technique and became the first person to deliberately introduce an opaque substance into the respiratory tree of a living patient for the purpose of roentgenographic diagnosis. Two years later, Lynah and Stewart demonstrated lung abscesses by bronchial mapping with a mixture of bismuth subcarbonate in sweet oil instilled via a bronchoscope, while in France, Sicard and Forestier noted that a nonirritating iodine containing substance, lipiodol, developed for subcutaneous injection in "chronic iodine therapy" cast very opaque roentgenographic shadows. In 1921, they proposed its use as a bronchographic agent. Despite Manges' resistance, the technique won many advocates and though technical details were debated for several

years, lipiodol bronchography was not improved upon significantly until the advent of the water soluble opaque media over thirty years later.

The major technical advance of the post-war era lay in the introduction and popularization of the Potter-Bucky diaphragm. Gustave Bucky had designed his first grid for roentgenographic work in 1913, but it produced an intolerable pattern on the film and never won acceptance. In 1915, he patented a moving grid; however, there was no evidence that he solved the problem of grid lines. In 1917, Hollis Potter first described his moving, parallel member, focussed grid, but, chided by Caldwell for his ignorance of Bucky's 1915 patent, he didn't publish his work until 1920. Only then did it become possible to record details of thick body parts roentgenographically; only then do we begin to find notes on the value of lateral and oblique projections in chest roentgenography (Evans, 1921). At Eastman Kodak Company, this interest in the problem of controlling scattered radiation led Wilsey to undertake his famous analysis of secondary radiation. There, too, interest in the production of noninflammable film led to the development of cellulose acetate base film which became available in 1924.

The First International Congress of Radiology in 1925 marked the post-war reestablishment of contact with radiologists of other nations, and marked the end of the era.

1926–1932

No single predominant influence can be identified in the development of chest roentgenology from 1926 to 1932. It was a period of consolidation—old techniques were perfected, criteria for specific etiologic diagnoses were developed, and like the pioneering period, its developments foreshadowed the technical progress of the subsequent generation.

Concern for the public welfare became apparent and one finds Opie in 1928, discussing the necessity for tuberculosis detection "for the good of the public health." Maxwell in 1927–1929, advocated chest roentgen examinations for army "recruits and overseas replacements" pointing out that such examinations were not an expense, but actually in the interest of national economy. In the early 30's, silicosis also became a major issue of public health. The disease became compensable in various states after 1930, and perhaps because of the economic crisis, the courts were flooded with claims for compensation. Only then, was the work of Pancoast and Pendergrass fully comprehended. Their work continued, and Jarvis and others contributed further to the knowledge of pneumoconioses.

There was also a beginning appreciation of the problem of lung cancer in this era. Hyde and Holmes in 1927, noted that it was "not so rare as is commonly believed," and it was the subject of Graham's Caldwell Lecture in 1933. Still, however, the significance of the entity was not fully appreciated.

Those attempting to discuss diagnostic criteria in various pathologic states felt an increasing need for standards of normalcy. The work of Pancoast, Baetjer and Dunham in 1927 (subsequently revised by Pendergrass and Hodes) is still the accepted standard for the appearance of "The Healthy Chest." During this era, clinical interest turned to the manifestations of Friedländer's pneumonia, pulmonary mycoses, and pulmonary infarcts. Pinner discussed tuberculous cavities and their surgical management, and the azygos lobe was for the first time positively identified.

Interest in cardiovascular lesions during the 20's was focussed mainly on the orthodiagraphic measurements but in 1930, one finds Steel's paper on valvular lesions, and Hampton's contribution on aortitis. Interest in the diagnosis of congenital cardiovascular anomalies, especially coarctation, began.

The major new technical advance of the period was the rotating anode tube. Conceived in 1897 (Wood), and patented in

1914 (Thompson), it was 1929 before Bouwers announced the first commercially available model. Kymography was also perfected in this era though not widely used until 1935 and after. Finally, the period saw the beginning of the development of laminagraphy (Bocage, 1921; Vallebona, 1931), "high kilovoltage" roentgenography (Stephani, 1929), ultrafine focal spots (Grödel, 1925), and angiocardiography (Forsmann, 1931). With the general availability and application of some of these developments, another era began.

1933–1942

Interest in the public health had been developing in the previous period but became the dominant force in the years from 1933 to 1942. Interest developed particularly in surveys of large population groups for the detection of tuberculosis. This idea was not new—a roentgen survey had been made in 1911, in South Africa, and two of the old regiments of World War I had been similarly screened. (The Surgeon General opposed screening all recruits at that time for several reasons including the expense and the problem of storing the plates.) The roentgenogram was acknowledged to be the ideal medium for the detection of incipient tuberculosis, but mass roentgen surveys with conventional techniques were impractical. The major contribution of these years was the development of photoroentgenography and photofluorography for this sort of study.

Bleyer had described a "photofluoroscope" for photographing the fluorescent screen in 1897, and Köhler, among others, had participated in the early development of the technique. Caldwell had correctly concluded that the camera would record more detail than the eye could see on the fluorescent screen, and had predicted that the method would have great value ultimately. Various workers, particularly in France and Germany, had improved the technique through the 20's and early 30's. In 1936, de Abreu in Brazil successfully used 35 mm. chest photofluorography and did much to popularize the method. The technique was extensively employed in Europe by 1938, while in this country, Potter developed his photoroentgen technique utilizing 4 by 5 inch films. Through Lindberg, Hirsch and others, 35 mm. photofluorography was also introduced into this country and Hilleboe, Hodges and Morgan were particularly active in its development. The Morgan-Hodges phototimer, introduced in 1942, was initially devised for photofluorography though subsequently modified for general roentgenographic application. Numerous comparative studies indicated that the miniature chest film was a reliable case finding medium and by the end of this decade, the techniques were in general use.

With the introduction of the sulfonamides in 1937, interest in the bacterial pneumonias diminished, but several new entities had been described during the period. These included Pancoast's superior sulcus tumor (probably carcinoma of the lung), lipoid pneumonia, interstitial pneumonitis, and several of the "collagen diseases." The development and resolution of pulmonary edema were recorded, and the pulmonary changes in azotemia were documented. Finally, interest in the roentgen diagnosis of cardiovascular disease focussed more and more sharply on congenital anomalies, and Roesler considered these in an excellent paper in 1939.

Multiple slit kymography came into general use in 1935, and enjoyed wide popularity for the subsequent ten years. Sabat had first described the technique in 1911, Gott and Rosenthal had developed it further in 1912, and Crane had built a single slit kymograph in 1916. The limitations of the available generators, however, had prevented its general acceptance. In 1928, Stumpf had renewed interest in the method and had described a multiple slit kymograph. Hirsch's contribution in 1934, consisted of a polygraphic recording system for kymogram, electrocardiogram, and heart sound tracings.

The popularity of the kymogram re-

flected the growing desire of the profession to record dynamic processes, and the development of a more fruitful approach to this problem, angiocardiography, culminated in 1938 with the work of Robb and Steinberg. These workers succeeded for the first time in visualizing the chambers of the heart and the aorta by making serial exposures following the injection of 70 per cent diodrast into the median basilic vein. Several others, including Castellanos and Lopo de Carvalho had contributed to the development of this technique after Forsmann's initial efforts in 1931. Laminagraphic units became available in 1935, and have been widely used ever since in the study of pulmonary abscess, cavitation, and neoplasm. Interest in demonstrating the mediastinum led to the introduction of diagnostic pneumomediastinum, and in Germany, some work was done with the injection of an opaque medium into the anterior superior mediastinal space.

The decade ended with W. E. Chamberlain's brilliant Carman Lecture on "Fluoroscopes and Fluoroscopy" (1942) which represented the first real application of optical physiology to the problems of roentgen diagnosis.

1943–1946

War once more determined the course of radiology during the years following Pearl Harbor. The development of photofluorography had set the stage for the routine screening of military personnel and tremendous experience in the miniature survey chest film techniques was gained during the war years. American forces saw duty in many different zones and references to previously inconsequential tropical diseases became common. The pulmonary manifestations of the fungal diseases were much discussed, and the presence of military installations in the San Joaquin Valley was reflected in a particular interest in coccidioidomycosis. Other evidence of the war was seen in discussions of the pulmonary findings in blast injuries and poison gas inhalation.

At home, the pulmonary findings in cases of kerosene ingestion, arteriovenous aneurysm, Löffler's syndrome, and acute interstitial fibrosis were described. Neuhauser called attention to a variety of intrathoracic vascular anomalies, and Robbins, in 1945, published his excellent discussion of lobar and segmental collapse. In 1941, Sussman, Steinberg, and Grishman described a "rapid film changer for use in contrast angiography for those discouraged with the poor detail obtained with photofluorographic techniques and the haphazardness of two film techniques." Their subsequent contributions to the literature of angiocardiography were notable.

1947–1956

By the beginning of the post-war decade, bacterial pneumonias had become rarities, the conquest of tuberculosis through specific antibiotic agents was at hand, and the radiologist was able to focus his attention on new diagnostic problems. The most notable of these was carcinoma of the lung.

Carcinoma of the lung had been discussed for over twenty years but the radiologist's interest in its specific diagnosis had remained largely academic because, though Graham had performed the first successful pneumonectomy for carcinoma in 1933, thoracic surgery in the 30's was hazardous and little progress had been made in the treatment of the disease. In the years immediately following the war, however, men who had had extensive experience with military thoracic surgery returned to civilian practice, the old chemotherapeutic agents were augmented by antibiotics, and a new knowledge of anesthesia and of postoperative management was brought to bear on the problem. As the result of the interplay of these factors, thoracic surgery progressed swiftly, and carcinoma of the lung came to be regarded as a curable neoplasm. Much interest was, therefore, focussed on the establishment of specific roentgenographic criteria for the diagnosis of bronchogenic carcinoma. In the course of these intensive studies, new entities

including pulmonary adenomatosis and pleural mesothelioma were characterized, but no consistent pathognomonic criterion of pulmonary malignancy was found.

Despite the advent of surgical therapy for the disease, the death rate from lung cancer continued to mount at an alarming rate, and interest developed in the earlier detection of such lesions by photofluorographic case-finding surveys. These studies are still in progress, and to date, the results have been very discouraging (Boucot). Germane to this possible failure of the mass survey technique in the control of carcinoma of the lung are the studies of Garland and others concerning the reliability of diagnostic roentgenographic procedures. Their disquieting findings have demonstrated the fallibility of present methods of survey film interpretation, and have suggested, among other improvements, double reading techniques. Other studies (Greening) have indicated the inadequacy of conventional roentgenographic techniques for the demonstration of certain types of intrathoracic lesions. These findings have led to the experimental use of supervoltage radiation for diagnostic chest roentgenography (Tuddenham, 1953). However, the control of lung cancer remains essentially an unsolved problem—no pathognomonic roentgenographic sign of malignancy has been found and no reliable, practical technique for its demonstration has been developed as yet.

The further development of angiocardiography has been another important trend in the post-war period. The fact that angiocardiography was available at a clinical level by 1946–1947, undoubtedly contributed to the rapid development of cardiac surgery in the post-war years. It is interesting to note that as recently as 1943, Sosman in discussing six "curable" cardiac lesions cited only two—patent ductus and constrictive pericarditis—which were amenable to surgery. Today even valvular lesions and septal defects are being corrected surgically. The cardiac surgeon's demand for yet more specific information, however, concerning the dynamic processes of the cardiovascular system has emphasized the importance of three major technical advances of recent years—the image amplifier, the high tension switch tube, and cineroentgenography.

Image amplification was perhaps first conceived by Langmuir who was granted a patent for an electron tube amplifier in 1939. Chamberlain predicted the application of television to the problem in 1942, and in 1948, Moon and Coltman described their respective amplification systems. Not until 1951, however, did Morgan report his first practical unit, and only in the past two years, have commercial units of the electron tube type been available for clinical use. Williams has yet more recently discussed the possibility of a photoelectroluminescent amplifier, and further development of this more compact system is eagerly anticipated. The high tension switch tube (Dotter) is a new concept, and has been designed to permit angiocardiographic exposures of such short duration that no perceptible motion of the opaque bolus occurs during an exposure. It is believed that the device will give hitherto unobtainable information concerning the dynamics of blood flow.

Roentgen cinematography is, on the other hand, one of the oldest and most elusive methods in diagnostic roentgenology. Macintyre's work in 1897, was probably the first attempt at its development, while Köhler in 1907, attempted to employ the technique in analyzing the mechanics of ventilation. Interest in its development has persisted throughout the intervening years, and the history of roentgen cinematography has been intimately associated with that of photofluorography, kymography and image amplification. Workers too numerous to mention have participated in its progress and among those most active at the present time in this country are Ramsey, Miller, Morgan and their coworkers. Owing to the efforts of these groups, the roentgen motion picture has become a clinically practical reality within

the past few months, and commercial units have recently become available. After almost sixty years, Macintyre's vision has at last been fulfilled.

Thus, we have traced the growth of chest roentgenology from the day of the pioneer radiologists to the present time. Obviously, it has been impossible to mention a great many of the important contributions of these years. It is hoped, however, that from this review one can derive some concept of the factors which have contributed to the development of the specialty. Chest roentgenology has progressed primarily by virtue of the vision and industry of the men of the profession; it has progressed by virtue of cooperation with other medical disciplines; it has progressed by virtue of the skill and inventiveness of those who have developed the amazingly complex instruments with which we work. For almost sixty years the dominant interest in chest roentgenology was the control of tuberculosis. Roentgenology, chemotherapy and surgery have virtually conquered that disease, and it appears that the control of bronchogenic carcinoma will be the next major goal. Armed with a new array of diagnostic implements the radiologist looks forward to a challenging future.

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ROENTGENOLOGIC EVALUATION OF PULMONARY FUNCTION

A CORRELATION WITH PHYSIOLOGIC STUDIES OF VENTILATION*†

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UNTIL recently, the measurement of pulmonary function was confined largely to the measurement of vital capacity. New developments in the evaluation of pulmonary function by physiologic tests have made it possible to obtain objective information about a variety of components of pulmonary function.[4,6] This has aided considerably in the understanding of pulmonary physiology in health and in a number of cardiopulmonary diseases. However, application of these new tests has been limited by the fact that many of them require expensive apparatus not readily available, skilled physiologic assistants, and considerable time and effort. Because of this, it seemed useful to determine what might be learned about pulmonary function by the full use of roentgenologic techniques, since roentgen equipment is available in every hospital and in many physicians' offices. Toward this end we have, for the past several years, correlated roentgenologic observations with physiologic tests. We have found that, in many instances, the well-trained, alert radiologist can evaluate function with surprising accuracy and in some cases can identify the specific nature of the abnormality which has been characterized only in more general terms by the physiologist.

PHYSIOLOGIC TESTS OF PULMONARY FUNCTION

We shall describe briefly the important factors underlying physiologic methods available for study of the lungs. The lungs have a relatively simple function, that of gas exchange. No complicated processes of secretion are involved for either the uptake of O_2 or for the elimination of CO_2. To effect normal oxygenation, for example, three processes are required: (1) alveolar ventilation, (2) diffusion across the alveolar-capillary membranes, and (3) pulmonary circulation. The first of these is concerned with the maintenance of an adequate alveolar O_2 concentration; the latter two are concerned with the removal of O_2 from the alveolar gas. A correct balance between supply and removal must be maintained for efficient function.

This paper will be limited to a discussion of ventilatory problems in which the primary disturbance is in maintaining an adequate ventilation of the lung as a whole, without undue expenditure of energy. We shall not discuss cases in which the primary disturbance is impaired diffusion or uneven ventilation in relation to pulmonary capillary blood flow. It is true that most of the cases we shall report are not pure disturbances in ventilation, for such are very rare indeed; nevertheless this somewhat arbitrary and artificial separation serves the useful purpose of focusing attention on pulmonary ventilation.

Ventilation is a cyclic process of inspiration and expiration in which alternately fresh air enters the respiratory tract and an equal amount of pulmonary gas is exhaled. It is important to define several terms:

1. *Tidal volume* (depth of breathing) is the volume of gas inspired or expired per breath.
2. *Minute volume* is the total volume of

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gas that enters the nose and mouth per minute. Minute volume = tidal volume × frequency.

3. *Alveolar ventilation* is the amount of inspired gas which enters the alveoli each minute. The respiratory tract is composed of the conducting airway (nose, mouth, pharynx, larynx, trachea, bronchi, and bronchioles) and the alveoli. Rapid gas exchange of O_2 and CO_2 occurs only in the alveoli, and not in the conducting airway. For this reason, the estimation of the amount of fresh air reaching the alveoli (alveolar ventilation) is much more important than the measurement of minute volume of breathing.

Alveolar ventilation = (tidal volume − dead space) × frequency. If, for example, the tidal volume is 200 ml. and the frequency of breathing is 40 per minute, minute volume = 200 × 40 = 8,000 ml. per minute; this is a normal value. However, if the dead space volume = 150 ml., the alveolar ventilation = (200 − 150) × 40 = 2,000 ml. per minute; this is definitely an inadequate volume to arterialize the venous blood.*

It is obvious that alveolar ventilation per minute may be decreased either because the tidal volume is reduced, the respiratory dead space is increased, the frequency of breathing is slow, or because of a combination of these.

Clinically, frequency of breathing is counted routinely. Tidal volume is rarely measured though it can be determined easily by the use of a Benedict-Roth or other type of basal metabolism apparatus. Inspection as a means of measuring thoracic excursion is often deceiving, particularly when there is airway obstruction; the effort may be great, but the tidal volume small. The depth of respiration can be estimated by a fluoroscopic study of costal and diaphragmatic excursion during the resting state or by obtaining roentgenograms in inspiration and expiration for comparison.[14] Similar information may be recorded on a single roentgenogram, exposed twice, once at the peak of normal inspiration and again at expiration. Unfortunately there are no quantitative data indicating the minimal volume changes that can be determined roentgenologically by comparison of inspiratory and expiratory positions of the ribs or diaphragm. It is our impression, however, that small changes in volume which can be measured spirometrically by the physiologists are difficult to detect roentgenologically. For these reasons, the only satisfactory measurements of tidal volume at the present time are the physiologic ones. Respiratory dead space is more difficult to measure; in the calculation of alveolar ventilation it is permissible to use approximate values for dead space (100 ml. for females, 150 ml. for young males, and 180–200 ml. for males past fifty years of age).

Normal values for alveolar ventilation vary with the metabolic activity of the individual; in general, an alveolar ventilation of 4–5 liters per minute is adequate for a resting adult. Since a reduction in alveolar ventilation leads to anoxemia and CO_2 retention and both of these stimulate breathing and so increase alveolar ventilation, hypoventilation can occur only when (a) there is a depression of the reflex or central mechanisms regulating breathing, (b) there is a nervous or neuromuscular disturbance involving respiratory pathways or muscles or (c) there is serious change in the physical properties of the lungs and thorax which mechanically limits breathing. The complete analysis of patients with hypoventilation, therefore, involves not only the actual measurements which show that hypoventilation exists,

* Alveolar ventilation may also be calculated from measurements of expired CO_2 and alveolar CO_2 concentration. When there is uneven ventilation in relation to blood flow, the alveolar ventilation calculated from these data will be less than values calculated from tidal volume, frequency and anatomic dead space. In this paper, we have calculated alveolar ventilation on the basis of anatomic dead space, assuming that distribution is uniform. Since distribution is rarely uniform, values presented here for alveolar ventilation are really the maximal possible volumes of alveolar ventilation in each case. The subject of uneven alveolar ventilation will not be discussed in this paper; for a discussion of non-uniform ventilation, see reference 4 and 10.

but also the use of those procedures which identify the factors responsible for the hypoventilation. In addition it is important to know whether the muscular effort required to achieve ventilation is increased.

Few patients with pulmonary disease actually have a decreased minute volume of breathing or decreased alveolar ventilation (based on measurements of rate, tidal volume, and anatomic dead space). However, many patients must do an increased amount of muscular work to achieve adequate ventilation. This work is required to overcome the elastic recoil of the lung (on inspiration) and tissue and airway resistance (on both inspiration and expiration). The total work of ventilating the lungs and the fraction of the total work expended in overcoming elastic recoil, tissue resistance and airway resistance can now be measured independently and objectively by physiologic tests.[2,4,15] Such measurements are often required in order to determine the specific mechanical defect in breathing.

IDENTIFICATION OF FACTORS RESPONSIBLE FOR DISTURBANCES IN VENTILATION

A. *Physiologic Tests and Methods.* The normal tidal volume is 500 ml. but the inspiratory capacity (the maximal volume of air that can be inspired from resting expiratory level) is about 3,500 ml., and the expiratory reserve (maximal volume of air that can be exhaled from the resting expiratory level) is about 1,000 ml. in healthy adult males. The sum of these two, the vital capacity, represents the maximal volume that can be expelled after a maximal inspiration.

These volumes can be measured easily by requiring the patient to breathe into the Benedict-Roth or other type of basal metabolism apparatus. Separation of the thoracic and diaphragmatic components of vital capacity can be done only roughly by the physiologist, *i.e.*, by measurement of the circumference of the chest by a tape, or by percussion over the area of diaphragm during inspiration and expiration. Such differentiation is performed more accurately by roentgenologic techniques.

Actually, a reduction in vital capacity must be very drastic to be solely responsible for hypoventilation. This might occur in a patient with poliomyelitis who has a vital capacity which is less than the normal tidal volume and who cannot increase his rate of breathing sufficiently to achieve normal alveolar ventilation.

The vital capacity does not represent total lung volume; some gas (residual volume) cannot be expelled by maximal expiratory effort, and must be measured by indirect means.[6] The value so obtained, added to vital capacity measured spirometrically, gives a figure for total lung capacity. An increase in residual volume is often interpreted to mean that alveolar ventilation is interfered with. Actually, all it signifies is that the lung is still hyperinflated even after full expiration. This increased amount of air in the lung does not mean that alveolar ventilation is decreased or increased. Alveolar ventilation depends upon a to and fro cyclic movement of air, and not upon the static volume. However, an increased residual volume may give a clue to the nature of the pulmonary disease, since hyperinflation may be due to predominantly expiratory obstruction, to diminution in pulmonary elasticity or to fixation of the chest in the inspiratory position by developmental or other pathologic processes. Decrease in residual volume usually indicates the existence of fibrotic shrinkage or of a process causing compression or encroachment on alveoli. The total lung capacity may remain normal even when the vital capacity is decreased if the residual volume is increased correspondingly; this is often seen in asthma and emphysema.

The ability of a patient to breathe deeply and rapidly also gives a clue to the nature of a ventilatory defect. This can be tested by measuring the maximal breathing capacity (M.B.C.), by recording the velocity of air flow with an electrical or mechanical flow meter, or by analysis of inspiratory and expiratory tracings obtained by re-

quiring the patient to inspire and expire at maximal force and speed.[4,5,6,15] All of these measure essentially the same function. The maximal breathing capacity is used most widely at the present time. It measures the ability of a patient to breathe at sustained high velocity and so depends not only upon vital capacity but also upon other factors such as muscular force, patency of airways, and the physical properties of the lungs and chest wall. The maximal breathing capacity may be reduced out of proportion to a decrease in vital capacity in patients who have obstruction of the airways or decreased elasticity of pulmonary tissues. On the other hand, the maximal breathing capacity may be fairly well maintained in some patients with restrictive lesions such as certain types of pulmonary fibrosis,[16] even though there be marked reduction in vital capacity. Unfortunately the maximal breathing capacity, like the vital capacity, depends upon so many factors that a low value indicates merely that an abnormality exists and is not pathognomonic of any single disease.

As mentioned previously, techniques for measuring the specific mechanical factors involved in breathing are now available but require specialized equipment and cannot be carried out readily in every hospital laboratory at the present time.

Finally, a patient may be hypoventilating but have no mechanical limitation to breathing. In such a case, one must suspect that there is depression of respiratory centers or of the nervous pathways or of the respiratory muscles. This may be identified physiologically by determining whether the respiratory response to inhalation of 7.5–10 per cent CO_2 is normal.

B. *Roentgenologic Studies.* There are many anatomic abnormalities which reduce vital capacity and can be demonstrated in roentgenograms of the chest.[1] These include anomalies in development of vertebrae or ribs, scoliosis, deformities of the thoracic cage due to fractures, thickened pleura, and space-taking lesions within the chest. Lesions affecting the position and mobility of the diaphragm may seriously reduce vital capacity. Changes in the interstitial tissue caused by edema or granulation tissue are often associated with reduction in total lung volume. These may be manifest as a faint haze, giving a "ground glass" appearance to the lung fields. Unfortunately no quantitative studies have been done of the minimal amounts of pulmonary edema fluid that can be detected roentgenologically.

It should be possible to obtain a reasonably accurate determination of the volume of each half of the thoracic cavity by planimetric measurements on films of the chest exposed in the posteroanterior and lateral views, as has been done in the measurement of roentgenologic chest volume.[3] However, this includes the volume of the heart and great vessels, the mediastinal structures, the pulmonary blood and interstitial tissue as well as that of the alveolar gas. It does not seem possible to estimate lung volumes consistently by the application of any factor. The reliability of any such roentgen estimation is practically nil if disease, particularly diffuse disease, is present in the lungs or pleura.

In each patient the radiologist should observe the changes that occur in the size of the thorax during forced breathing and if possible relate these to the vital capacity measured spirometrically in the roentgenologic department; in this way he will increase the value of his clinical judgement regarding ventilation. While fluoroscopic observation during continued forced respiration can give only a general impression of the dynamic reserve of the lungs, one can be certain that a rapid respiratory effort coupled with marked change in volume of the thoracic cage and elevation and separation of ribs will result in the movements of large amounts of air in a given period of time. Conversely, if the patient is instructed to perform a maximal breathing capacity test and there is little change in position of the ribs, maximal breathing capacity is certain to be reduced. Additional analytical information can be obtained by

studying the position of the diaphragm at rest, and its rate and degree of movement during forced respiration, coughing and sniffing, with the patient erect and recumbent. In certain instances, as in unilateral paresis or paralysis of the diaphragm, more data concerning the dynamics of respiration may be obtained by observing the individual in each lateral recumbent position with the aid of the horizontal roentgen beam. Limitation of movement of the diaphragm as observed fluoroscopically during attempts at maximal breathing, indicates serious impairment of ventilatory function. Finally the rate, extent, and symmetry of change of the various parts of the lungs should be observed during quiet and forced breathing, cough, and when intrathoracic pressures are altered as in the Valsalva and Müller procedures. Unchanging radiolucency or density of a localized portion of the lung field indicates absence of ventilation with a consequent reduction in vital capacity.[11] Of great importance is the symmetrical fanning and converging of vascular lung markings in the midzone of the lung fields as emphasized by Golden;[9] restriction or irregularity of these movements indicates decreased expansibility and decreased vital capacity.

The contribution of bronchial obstruction to a reduction in maximal breathing capacity may be analyzed roentgenologically. The functional integrity of the bronchial tree may be studied, after instillation of radiopaque material, by roentgenograms made in inspiration and expiration. As Macklin[12] has shown, the normal bronchi and bronchioles elongate, widen and separate during inspiration and this process is reversed during expiration. Alterations in the normal pattern of bronchial movement parallel similar abnormal movements of the vascular shadows as described above, and are of prime importance in evaluating disease or incompetence in the framework tissues of the lung. This information is particularly applicable in investigating the cause and prognosis of bronchiectasis. Furthermore, evidence of increased tone of the bronchial musculature in asthma and emphysema is often suggested by bronchography which may demonstrate bronchioles fixed in the inspiratory pattern.

On the other hand, qualitative changes in rate and muscular activity cannot be translated into the quantitative terms necessary to give meaning to the concept of maximal breathing capacity, particularly if one sees anatomic changes in the lung fields.

Much additional information concerning possible causes of hypoventilation may be obtained by extending the fluoroscopic study. The nasopharynx, oropharynx, hypopharynx, and larynx should be examined for abnormalities such as obstructive lesions. Similarly, the position and function of the uvula, base of the tongue and vocal cords should be observed. Furthermore, important changes in the position, caliber and rigidity of the trachea and main bronchi may be revealed by fluoroscopy and suitable films of the neck and chest. The configuration of the thoracic cage is important in any attempt to assay mechanical limitations to breathing because thoracic deformities hamper the respiratory act. This information is obtained readily by rotating the patient behind the fluoroscopic screen. It is seen that the radiologist may go further than the physiologist by determining the actual cause of hypoventilation in some cases.

REPORT OF CASES

Seven cases are presented which illustrate the usefulness and limitations of roentgenological evaluation of pulmonary function, and how roentgenologic and physiologic tests complement and supplement each other.

Case 1. F.E. was a forty-six year old white male admitted to the hospital because of dyspnea, cough and ankle edema. He had congestive heart failure and gross deformity and fixation of the thoracic cage.

The roentgen study showed barely perceptible movement of the ribs and diaphragm during maximal respiratory movement. It also revealed deformity of the thoracic cage, which

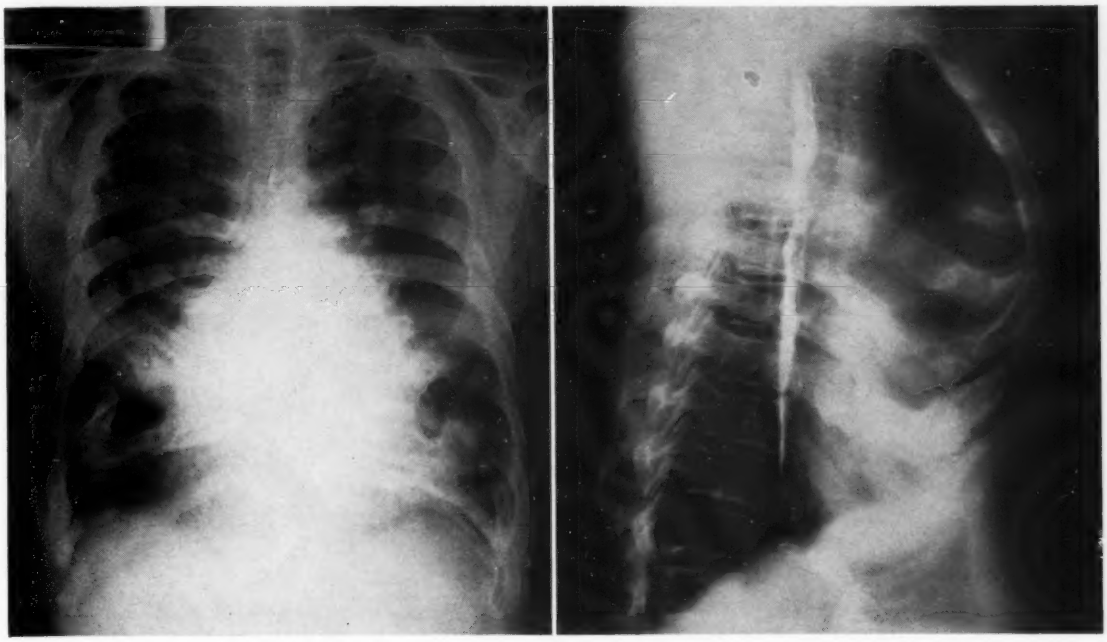

FIG. 1. Roentgenograms of the chest of a forty-six year old white male with congenital chondroplasia, pulmonary insufficiency, and incipient cardiac failure. Note the deformity of the anterior ends of the lower ribs and the shape of the bony thorax. The chest wall and diaphragm are fixed in the attitude of maximum inspiration. Under these circumstances, an extremely reduced vital capacity, total lung capacity and maximal breathing capacity may be expected.

was fixed in the inspiratory position and presented the appearance of congenital chondroplasia (Fig. 1). Accompanying the deformity of the chest was a marked reduction in the anteroposterior diameter of the thorax which resulted in flattening of the heart between the sternum and spine. From these findings, it was predicted that vital capacity and maximal breathing capacity would be low and residual volume high.

Pulmonary function data are shown in Table 1. It should be noted that although his total minute volume of ventilation was normal, his "maximal" alveolar ventilation was inadequate. This is because his tidal volume was 200 ml., only 75 ml. in excess of that required to clear a normal respiratory dead space. Even with a respiratory rate of 30/min., this patient achieved an alveolar ventilation of only 2.3 liters per minute. Consequently, his arterial O_2 saturation was low, he was unable to eliminate CO_2 properly and he developed a respiratory acidosis. He had an extremely low vital capacity, total lung volume and maximal breathing capacity. His residual volume was slightly increased. The residual volume/total lung capacity ratio (RV/TLC) was high largely because of the great reduction in total lung capacity.

Comment. This is an example of chronic ventilatory insufficiency produced by mechanical limitation to expansion of the chest associated with congenital deformity of the thoracic cage. This patient was unable to ventilate adequately at rest and could increase his ventilation only slightly by maximal voluntary effort. Congestive heart failure developed probably owing to longstanding anoxemia of the heart muscle, though mechanical interference with cardiac function might be another factor. The diagnosis in this case could have been made equally well by either the radiologist or the physiologist.

CASE II. E.O. was a thirty-nine year old woman known to have scleroderma involving the lower extremities and trunk up to the middle of the chest. Her chief complaints were dyspnea and fatigue. She developed cardiac failure and bilateral pleural effusion. She recovered from the congestive heart failure after

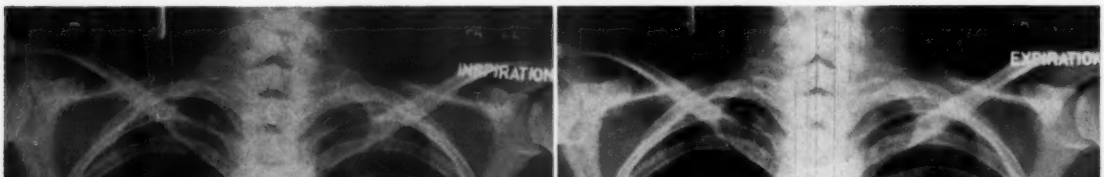

Fig. 2. Roentgenograms of the chest of a thirty-nine year old white woman complaining of dyspnea and found to have scleroderma involving the chest wall. The film on the left was obtained at maximal inspiration and that on the right at maximal expiration. Note that there is practically no change in the position of the diaphragm or of the individual ribs in the two films. One can predict that vital capacity and maximal breathing capacity will be markedly reduced under these circumstances. Cardiac enlargement, vascular congestion, and pleural effusion embarrass respiration further by encroaching upon the space in the chest available to air in the lungs.

a few days rest in bed.

The roentgen examination of this patient's chest showed that there were no visible abnormalities of the bones or joints which might cause limitation of vital capacity. The thoracic cage was not fixed in the inspiratory position. However, there was little movement of the thoracic cage with ordinary breathing, and there was marked reduction in diaphragmatic excursion. Roentgenologic examination was, of course, unable to determine whether this hypoventilation was due to neurogenic or mechanical factors, but it was evident that vital capacity and maximal breathing capacity were reduced. Additional roentgen findings were congestion in the small pulmonary blood vessels without enlargement of the left auricle (Fig. 2). There was no gross cardiac enlargement. There were bilateral pleural effusions estimated at approximately 300–400 ml. on the left and 100–200 ml. on the right. The dyspnea in this patient was undoubtedly increased by the pulmonary congestion and pleural effusions which further increased the effort required for pulmonary ventilation.

Physiologic data are summarized in Table 1. The vital capacity and total lung capacity were reduced markedly, largely because of marked decrease in inspiratory capacity. It is interesting to note that although her vital capacity was reduced to 30 per cent of predicted volume, the maximal breathing capacity was reduced to only 63 per cent of normal; this means that she was able to breathe at a very rapid rate, using practically her whole vital capacity with each breath. This finding eliminates obstruction or loss of elasticity as an important factor in her disease. Despite the shallowness of her breathing (230 ml. per breath) she was able to compensate by doubling her frequency of respiration; assuming an anatomic respiratory dead space of 90 ml., the alveolar ventilation was 34×140 or 4.8 liters per minute, a normal value. Because of this she maintained a normal arterial O_2 saturation, CO_2 pressure and pH. However she achieved this only by a considerable increase in the work of the respiratory muscles per minute.

Comment. This patient had mechanical difficulties in respiration caused by limitation of thoracic movement as a result of

TABLE I

	CASE I. F.E. (M)		CASE II. E.O. (F)		CASE III. L.F. (M)		CASE VI. J.W. (F)		CASE VII. G.B. (F)	
	Predicted Normal	Observed	Predicted Normal	Observed	Predicted Normal	Observed	Predicted Normal	Observed	Predicted Normal	Observed
Height		4'10"		5'		5'5"		5'2"		5'8"
Weight (lbs)		99		91		103		103		168
Age		46		39		45		28		39
Surface area		1.35		1.33		1.80		1.43		1.87
Minute volume (L/min.)	6.3	6.0	6.3	7.8	8.5	9.7	6.7	8.9	8.8	11.7
Tidal volume	394	200	394	230	530	690	420	355	550	336
Respiratory freq./min.	16	30	16	34	16	14	16	25	16	35
Respiratory dead space (estimated)	125		90		170		100		150	
Alveolar ventilation (L/min.) (TV-DS) ×f	3.3	2.3	4.9	4.8	5.8	7.3	5.1	6.4	6.4	6.5
Arterial O_2 saturation (%)	97.4	70.6	97.4	95.1	97.4	93.1	97.4	98.9	97.4	92.1
Arterial CO_2 pressure (mm. Hg)	40	77	40	42	40	45	40	36		
Arterial pH	7.39	7.32	7.39	7.40	7.39	7.37	7.39	7.42		
Vital capacity (liters)	4.00	0.885	3.040	0.900	4.100	3.520	3.140	1.300	4.325	0.950
Inspiratory capacity (liters)	3.20	0.573	2.280	0.470	3.280	3.180	2.425	0.630	3.243	0.809
Expiratory residual volume (liters)	0.800	0.330	0.760	0.470	0.820	0.560	0.715	0.480	0.087	0.184
Residual volume (liters)	1.300	1.662	0.940	1.566			1.1	0.824	1.305	1.399
Total lung capacity (liters)	5.30	2.565	3.980	2.506			4.24	1.934	5.602	2.392
RV/TLC ×100 (%)	24	65	24	62			26	43	23	59
Maximal breathing capacity (L/min.)	100	18	70.3	44.6	113	48	93.7	74.4	98.9	86.0
Vital capacity (mm. H_2O)			50–100	342				122		

scleroderma of the subcutaneous tissues about the thorax. Her respiratory difficulties and her function studies are similar to those which would occur if a normal patient's chest and abdomen were strapped tightly, or in patients with pulmonary fibrosis.[16]

The physiologic tests cannot, of course, determine whether the mechanical limitation was caused by a lesion in the chest wall or in the lungs. However, roentgenologic studies were able to exclude the presence of significant pulmonary fibrosis. The congestive heart failure and pleural effusion further hindered alveolar ventilation and increased the patient's work of breathing. Her cardiac failure might have been due to involvement of heart muscle and pulmonary arterioles by her scleroderma; measurements of pulmonary arterial pressure were not made.

CASE III. L.F. was a forty-five year old white male, steel welder, whose chief complaints were frequent coughs and colds for the past five years. He had mild dyspnea for several years, gradually increasing in intensity, and a small amount of thick, yellow sputum in the morning. Physical examination revealed bilateral wheezes, chiefly inspiratory, in the chest posteriorly.

The roentgen examination showed no abnormalities of the thoracic cage. Motion of the diaphragm and ribs was present, to a normal degree, although expiration was prolonged in time. This suggested an inability to move large amounts of air rapidly in and out of the lungs. Bronchograms were performed which showed uniform, unchanging elongation, separation and narrowing of the second order and smaller bronchi, which were fixed in the maximal inspiratory attitude even when films were exposed in the expiratory phase (Fig. 3). It was predicted that maximal breathing capacity would be reduced with little impairment in vital capacity.

His physiologic data are presented in Table I. His vital capacity was 86 per cent of predicted value but his maximal breathing capacity was only 42 per cent of normal. This points to an inability to move air in and out of the lungs rapidly. Such a patient need not have ventilatory insufficiency at rest but may develop it during exercise when greatly increased minute ventilation is required. The spirographic tracing was suggestive of predominantly expiratory obstruction since, after maximal inspiration, there was a gradual, step-like return of the tracing to the resting level. Arterial blood studies showed evidence of slight pulmonary insufficiency for O_2 and for CO_2.

Comment. This patient had mechanical difficulties in ventilation such as occur with obstruction in the bronchial tree or with emphysema. The roentgenologic findings were characteristic of asthma or asthma-like conditions (exaggeration of the normal

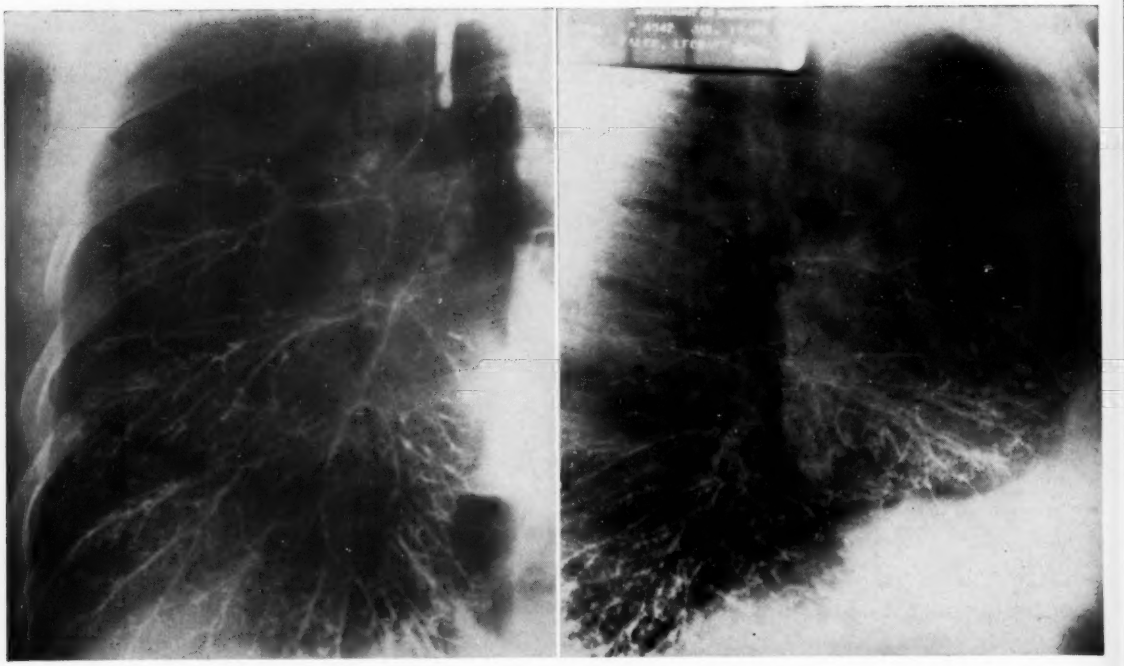

Fig. 3. Roentgenograms of the chest of a forty-five year old white male with chronic bronchial asthma, following instillation of lipiodol into the bronchial tree. Note the elongation, separation, and attenuation of the first and second order bronchi. The appearance is an exaggeration of that seen in maximal inspiration. The films were exposed at the end of expiration. Inability to deflate the lungs and diffuse narrowing of the bronchi are typical findings in chronic asthma. One can expect a marked reduction in maximal breathing capacity with this kind of partial obstruction of the airway.

inspiratory appearance persisting during expiration); these findings aided considerably in the interpretation of the pulmonary abnormality.

By extra effort, he was able to maintain a normal resting minute volume of breathing and an adequate volume of alveolar ventilation. Despite the fact that the volume of alveolar ventilation was normal (as calculated from tidal volume, frequency, and anatomic dead space) his arterial blood showed evidences of slight pulmonary insufficiency (anoxemia and CO_2 retention). This must have been due to uneven obstruction of airways leading to uneven distribution of the inspired gas and alteration in the normal relationship between alveolar ventilation and pulmonary capillary blood flow. *It is important to remember, then, that normal or high values for ventilation do not rule out a ventilatory disturbance.*

Case iv. S.L. was a twenty-eight year old white male who sustained a puncture wound in his foot and developed brachial and intercostal neuritis following the injection of tetanus antitoxin. Although his primary complaint was pain in the arms and shoulder muscles, he developed an unusual type of dyspnea which was characterized by inability to breathe when lying prone or supine. Routine fluoroscopic examination in the erect posture revealed no functional abnormalities. However, the films in inspiration and expiration showed elevation of the left half of the diaphragm. The right half of the diaphragm moved normally but the left moved only one interspace. There was no elevation of the ribs upon inspiration and the volume of the thoracic cage appeared to be reduced (Fig. 4).

The patient was studied before we began to correlate physiologic and roentgenologic studies. In retrospect, the radiologist could have made the diagnosis (organic weakness of the muscles of respiration) by precise measurements of chest volume and movements of ribs and diaphragm during forced breathing and rapid

sniffing, in the standing and supine positions with the use of the tilting fluoroscope. In the supine position, one might have detected a marked encroachment upon the air space in the lung, the heavy abdominal viscera pushing the weakened diaphragm well up into the thorax.

The diagnosis of weakness of the respiratory muscles was made in this patient by the following physiologic tests: When breathing was forced voluntarily or by inhalation of 10 per cent CO_2 there was no appreciable increase in the circumference of his chest. His vital capacity was 2,400 cc. when standing, but only 600 cc. when he was supine. His maximal inspiratory pressure was only 36 mm. Hg (normal, 86). When lying supine for fifteen seconds, his arterial O_2 saturation began to fall sharply and he became acutely dyspneic. When O_2 was substituted for air without his knowledge, he was able to lie supine for two minutes. He was comfortable for long periods lying supine in the Drinker respirator. Finally, when sleeping in the high Fowler position, he awoke immediately with severe dyspnea when the head of the bed was lowered slowly.

Fig. 4. Roentgenogram of the chest of a twenty-eight year old white man with partial paralysis of the diaphragm caused by peripheral neuritis. In the supine position the abdominal viscera displaced the diaphragm upward to such a degree that the vital capacity was only 600 cc. and the patient became markedly dyspneic within fifteen seconds after lying down. Even in the erect posture, his maximal breathing capacity was markedly reduced owing to weakness of the muscles of his chest wall as well as the diaphragm.

Comment. This case illustrates diminution in lung volume and limitation of ventilation owing to unusual mechanical compression by the abdominal viscera through a semiparalyzed diaphragm accompanied by failure of the other muscles of respiration caused by peripheral neuritis. Such mechanical interference with pulmonary expansion is seen more commonly with pleural effusion, pneumothorax and abdominal tumors, but its effects are less marked when the thoracic musculature is competent and the diaphragm has normal tone.

Case v. E.B. was a sixty-four year old white male with a diagnosis of bronchogenic carcinoma. The patient had an unusual type of dyspnea which occurred regularly within fifteen seconds after being turned on his left side.

Fluoroscopic examination showed limited motion of the left half of the diaphragm and displacement of the heart into the left chest. Films showed evidence of atelectasis of the left lower lobe and parts of the left upper lobe with narrowing of the ribs on the left side and upward displacement of the left half of the diaphragm (Fig. 5). It was thought that there was obstruction in the left lower lobe bronchus.

During the patient's attacks of dyspnea, the arterial O_2 saturation fell from 96 per cent to as low as 82 per cent. It appeared, therefore, that there was a potential obstruction to a main bronchus which became complete and resulted in atelectasis when he changed his position. During this time pulmonary capillary blood probably continued to flow through the nonventilated area, producing a shunt. This was confirmed by finding tht O_2 therapy raised his arterial O_2 saturation on one occasion from 87.8 to only 89.1 per cent. At this time his pCO_2 was 51 mm. Hg and his pH was 7.14 suggesting that the airway to an entire lung may have been occluded.

Comment. This case illustrates the profound physiologic effects that follow hypoventilation of a large part of the lungs caused here by obstruction of a large

Fig. 5. Roentgenogram of the chest of a sixty-four year old white male with carcinoma of the left main bronchus. His chief complaint was severe dyspnea when he lay on his left side. The film was obtained in inspiration. Note evidence of atelectasis in the left lower lobe. It was thought that the tumor represented a potential obstruction which became actual when the patient assumed certain positions. The symptoms emphasize the profound functional disturbances that usually accompany sudden atelectasis of a large area of lung.

bronchus. Anoxemia and cyanosis do not occur when ventilation and circulation of a portion of the lung are both cut off simultaneously (as in the ligation of the lung hilus preceding surgical pneumonectomy), but only when circulation continues through airless or poorly ventilated alveoli.[7] The patient's dyspnea resulted from a combination of respiratory stimuli: anoxemia, CO_2 retention and alveolar collapse.

Case vi. J.W. was a twenty-eight year old colored female with sarcoidosis involving the lungs. The patient's chief complaints were dyspnea, cough and increased expectoration.

Fluoroscopic study of the chest revealed no impairment in motion of the thoracic cage. Breathing was rapid and shallow. The diaphragm was restricted in motion to a moderate degree. Roentgenograms showed an extensive diffuse fibrosis of the interstitial tissue of both lungs without evidence of cardiac enlargement (Fig. 6) and from this it could be predicted that there was a marked reduction in lung volume and vital capacity, although the maximal breathing capacity might be little affected.

Pulmonary function studies are shown in Table 1. Her vital capacity and total capacity were reduced markedly but her residual volume remained normal. Though the vital capacity was only 41 per cent of the predicted value, the maximal breathing capacity was reduced only slightly, to 80 per cent. The minute volume of breathing was increased; such hyperventilation is typical of pulmonary fibrosis and helps to maintain normal arterial O_2 saturation, even though the diffusing capacity of the lungs is reduced.

Comment. This case is an example of hyperventilation caused by fibrosis of pulmonary alveoli. In this condition, the physical characteristics of the lungs are changed so that deep breathing becomes difficult and the patient breathes rapidly

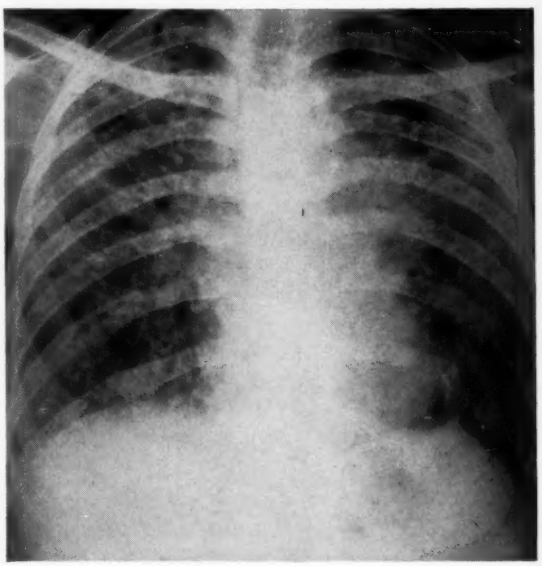

Fig. 6. Roentgenogram of the chest of a twenty-eight year old colored girl with sarcoidosis. Her complaints were dyspnea, cough and expectoration. Fluoroscopic examination showed no functional abnormality in the chest wall or diaphragm. Note the extensive, diffuse fibrosis depicted on the film. From these findings one can predict a marked reduction in total lung capacity and vital capacity, even though maximal breathing capacity might be maintained at a fairly normal level.

and shallowly. Recognition of extensive anatomic changes of this character on roentgenograms of the chest should lead to investigation of the ability of the patient to breathe rapidly, since patients with alveolar fibrosis do not have the marked reduction in maximal breathing capacity which often accompanies emphysema. Incidentally, the reduction in lung volume that occurred in this case could not have been detected by roentgenologic chest volume measurements because of the diffuseness of the lesions throughout the lung.

Case vii. G. B. was a thirty-nine year old white female with rheumatic heart disease, mitral stenosis and insufficiency, and aortic stenosis and insufficiency. Her chief complaint was dyspnea present even at rest.

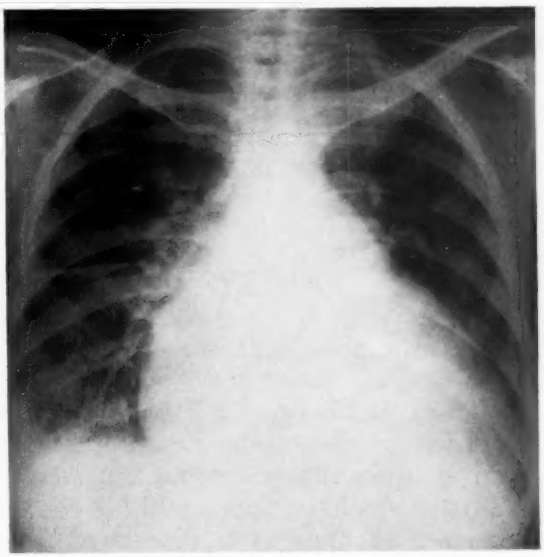

Fig. 7. Roentgenogram of the chest of a thirty-nine year old white female with rheumatic heart disease with mitral and aortic valvular stenosis. She complained of dyspnea even at rest. Fluoroscopic examination showed no functional abnormalities in the chest wall or diaphragm. Note in the film the marked encroachment on the available space in the chest by the dilated heart and bilateral pleural effusion. In addition, the original roentgenograms suggested edema of the interstitial tissues of the lungs.

Here again, one might expect a marked reduction in vital capacity without a commensurate decrease in maximal breathing capacity. This is the pattern of pulmonary compression without airway obstruction, similar to that found in fibrosis. It emphasizes the importance of pulmonary insufficiency which often accompanies cardiac failure.

Fluoroscopic study showed no fixation of the chest wall and good motion of the diaphragm. The roentgen examination showed a moderately enlarged heart with prominence of both large and small pulmonary vessels indicating the presence of pulmonary congestion. Collections of fluid were present at both right and left bases and possibly in the pericardial sac as well. In addition, there was a haze over both upper lung fields indicating interstitial edema (Fig. 7). Here again, one could predict a marked reduction in lung volume and vital capacity without concomitant reduction in maximal breathing capacity.

Pulmonary function studies are summarized in Table 1. There was a marked reduction in vital capacity and total capacity; the residual volume remained normal. The patient attempted to compensate for the reduction in volume by increasing her frequency of ventilation to 35/min. Although this must have increased her work of breathing, it maintained the minute volume and alveolar ventilation at normal levels. The reduction in arterial O_2 saturation was probably caused by impairment of diffusion brought about by slight pulmonary edema.[13]

Comment. This case illustrates marked change in pulmonary ventilation because of encroachment on the alveoli by distended pulmonary capillaries, pleural effusion and the enlarged heart. Such changes result in inability to breathe deeply without impairment of the ability to breathe rapidly.

DISCUSSION

It is evident that the extension of roentgenologic procedures to the evaluation of pulmonary function is a practical and desirable contribution to medical diagnosis. Since the emphasis in medicine today is upon earlier diagnosis and prevention of illness, it is important to turn aside from the older concept of disease as a pathologic anatomic entity and consider the derangements in physiology which are often its first manifestations. The roentgen examination is a tool in physical diagnosis and as such should be directed to the study of patho-

logic physiology whenever possible.[1] The various illustrations described above demonstrate some of the methods by which this can be done in the elucidation of abnormal pulmonary function.

Furthermore, increasing use of the roentgenologic method can be made in any investigative studies where physiologic patterns in health and disease are being analyzed. This application of roentgenology has come haltingly but its wider application in all fields of research is at hand. As an example, the gradual perfection of motion pictures of the images on the fluoroscopic screen now promises brilliant rewards to the investigators in many fields of physiology.

These considerations are of practical importance to scientists in all branches of biology and medicine because of the availability of roentgenologic apparatus in medical institutions in this country. From the standpoint of clinical medicine alone, qualitative information pertaining to pulmonary function, for example, may be obtained in almost every hospital and in many physicians' offices even though precise physiologic measurements of pulmonary physiology are not available. This fact should be recognized and roentgenologic methods used in the study of every patient where the possibility of abnormal pulmonary function exists.

Even when quantitative studies of pulmonary function can be made, the interpretation of the findings is aided by a correlation with the roentgenologic data. In addition, there are many instances where the two procedures are really complementary and not merely supplementary. Physiologic tests of the ventilatory capacity of the lungs give quantitative figures which result from the movement of many inter-related parts, some having gross motion, as the diaphragm, and some inconspicuous motion, as in the musculature of the bronchi and blood vessels. It is in the study and recording of some of these movements, that roentgenologic procedures play a significant role, and lead to information which may be used to interpret the results of physiologic tests or infer abnormal results if no tests are available. Furthermore, static shadows recorded on roentgenograms (for example, altered patterns of vascular markings in the lungs) should be interpreted in terms of the functional changes which they imply. By recognizing the physiologic implications which may be derived from anatomic roentgen shadows, one clothes this evidence with new significance.

Such roentgenologic information will be of importance in the evaluation of patients before surgical procedures upon the chest, and in determining the prognosis in a great number of medical conditions in which the lungs are involved either primarily or secondarily. Close application of these roentgenologic methods may uncover new problems which present physiologic tests cannot answer. In this way, the available, simple, easily conducted roentgenologic examination may stimulate more basic researches in pulmonary physiology.

CONCLUSION

1. General concepts of pulmonary physiology and specific laboratory methods of determining disturbances in pulmonary function have been discussed.

2. Various roentgenologic procedures which give qualitative information in regard to pulmonary function have been outlined and their use illustrated by appropriate case reports.

3. Wider application of readily available roentgenologic methods will yield valuable information in regard to the ventilatory capacity of the lungs where specific physiologic tests cannot be obtained.

4. Such information gained by roentgenologic means will be of importance in surgical evaluation of patients, and in medical prognosis, and may prove to be a stimulus to further research in fundamental pulmonary physiology.

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THE LORDOTIC POSITION IN FLUOROSCOPY AND ROENTGENOGRAPHY OF THE CHEST

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THE additional information obtained from the fluoroscopic and roentgenographic examinations of the chest in the lordotic position warrants its more general and frequent use. It is the purpose of this paper to demonstrate and emphasize its many advantages in diagnosis and its use in localization.

In our experience since 1938, this supplementary position has proved of value so often that we now use it routinely except in the following instances: (1) the survey type of examination, (2) routine re-examination of individuals with previously normal chest findings, (3) where the abnormality present is adequately demonstrated by the conventional posteroanterior roentgenogram, and (4) in those instances in which more accurate localization of the abnormality is not indicated.

The first two reports in the literature concerning the lordotic position were made independently in 1925. Baum and Black[1] termed the resulting film the "apical roentgenogram" and used it to demonstrate small areas of apical disease and apical cavities while Fleischner[5] called it the "Kreuzhohlstellung" and used it to demonstrate interlobar effusions in the major or oblique fissures. Since that time others have stressed the value of the lordotic position in demonstrating small areas of apical disease,[1,2,4,6,7,13,17] apical cavities,[1,2,6,7,11] interlobar effusions,[5,9,12,15,16,17] collapse of the right middle lobe,[2,11,12,14] and prominence of the outflow tract of the right ventricle and the pulmonary artery.[3]

In the usual posteroanterior position, because of the normal or increased upper dorsal kyphosis, the shadows of the posterior segments of the upper ribs are either very close together or actually overlap. Furthermore, the clavicular shadows always cross the upper lung fields (Fig. 1*A*). Therefore, abnormalities in the upper lung fields are frequently obscured by the superimposition of the shadows of these bony structures. The lordotic position widens the intercostal spaces between the posterior segments of the upper ribs and elevates the clavicles so that their shadows completely clear the apicalmost lung fields (Fig. 1*B*).

A careful and detailed fluoroscopic examination of the chest including examination in the lordotic position should be made before the initial roentgenograms are ordered. It is only by this method that one can determine which films are needed to demonstrate best, and to determine the location of, the pathologic or physiologic abnormalities present; or to give evidence pointing toward the absence of any suspected abnormality. Since at fluoroscopy the lordotic position so often gives valuable additional information, the lordotic roentgenogram should be frequently ordered.

The following paragraphs present, in approximate order of frequency, the various situations in which we have found the lordotic position of value.

Small areas of disease in the upper lung will commonly be demonstrated in the lordotic position (Fig. 1*B*) when evidence of disease is questionable or not visible in the usual posteroanterior position (Fig. 1*A*). Furthermore, even when signs of apical disease are clearly visible in the posteroanterior projection, one usually obtains additional information concerning its nature, extent and distribution from the lordotic position.

Cavities located in the upper portion of the lung are frequently (and those situated in the middle and lower parts of the lung are at times) much better demonstrated in the lordotic than in the conventional

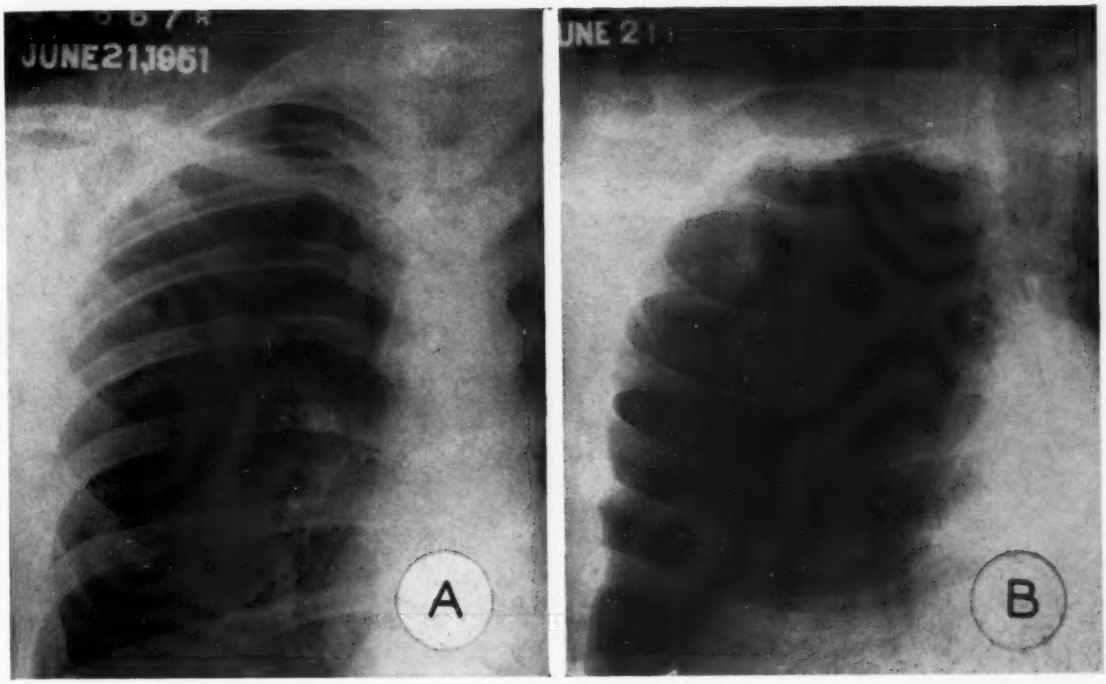

Fig. 1. (*A*) Posteroanterior roentgenogram. No visible evidence of disease because of superimposition of rib shadow. (*B*) Roentgenogram in the lordotic position. Evidence of disease is clearly visible.

posteroanterior position (including stereoscopic roentgenograms). At times, evidence of cavity, which is not even suspected in the posteroanterior position (Fig. 2*A* and 3*A*) will be unequivocal in the lordotic position (Fig. 2*B* and 3*B*).

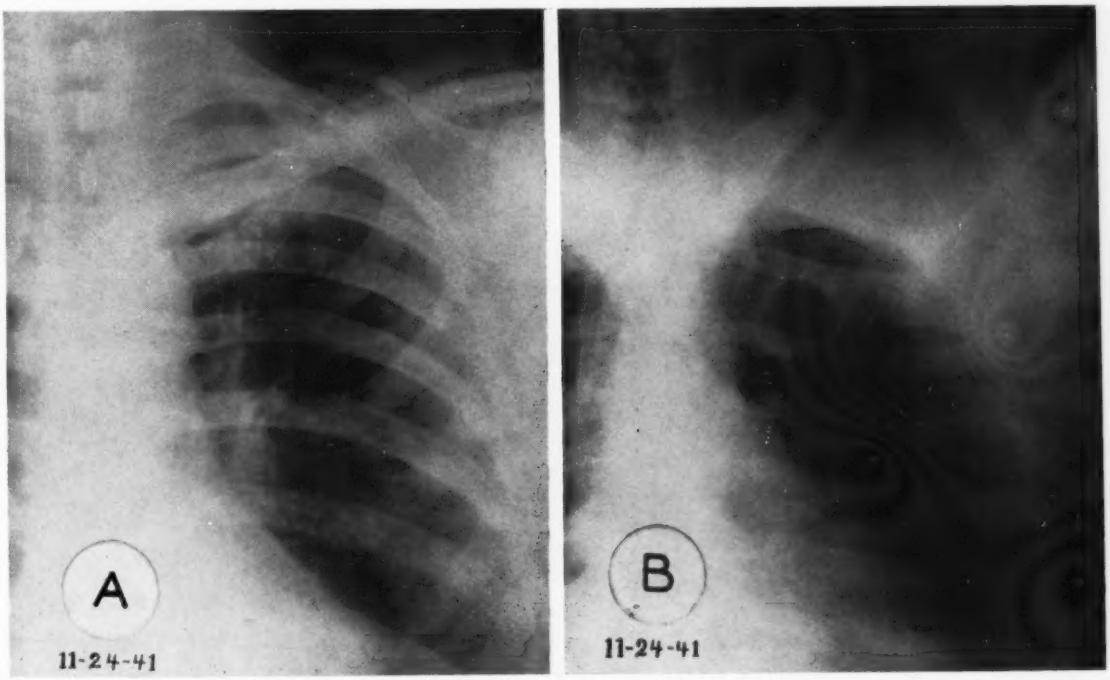

Fig. 2. (*A*) Posteroanterior. No visible evidence of cavity. (*B*) Lordotic. Evidence of cavity is unequivocal.

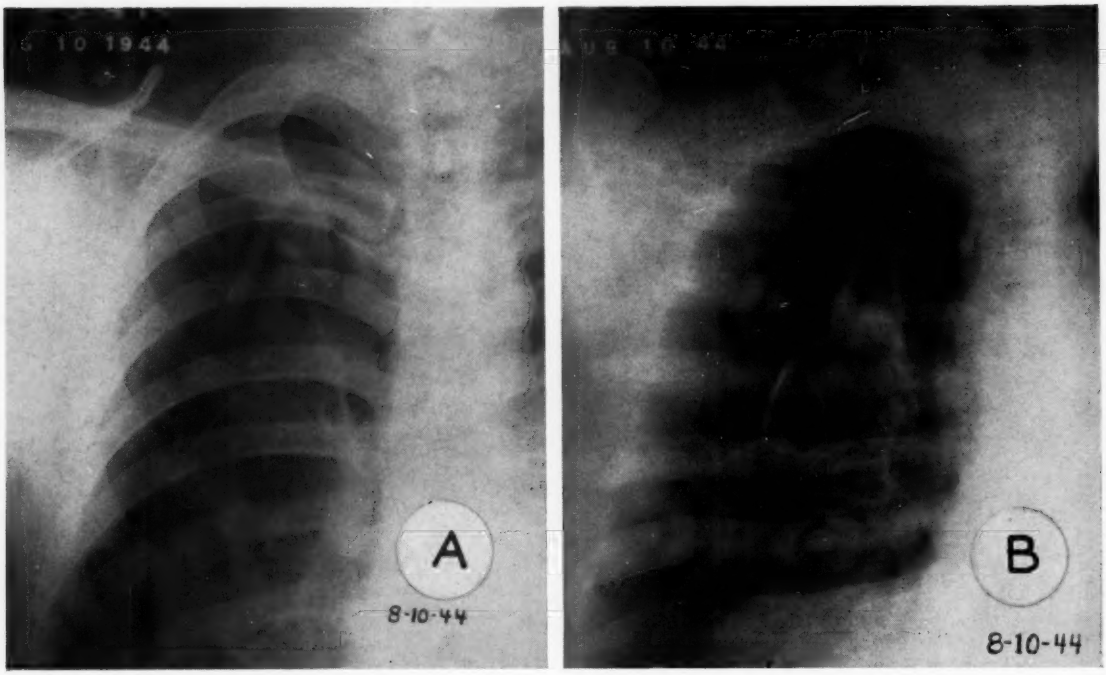

Fig. 3. (*A*) Posteroanterior. Evidence of cavity is very indefinite because of superimposition of the shadow of the anterior end of the first rib and its costal cartilage. (*B*) Lordotic. Evidence of persistent cavity in lung partially collapsed by pneumothorax is clearly visible.

Anterior mediastinal lung hernias are common in patients with "re-expanded pneumothorax" or with marked contraction of a considerable portion, or the whole, of one lung due to any cause. These hernias are best shown at fluoroscopy; are largest on maximum inspiration and usually decrease considerably in size on expiration. In our experience such hernias are almost invariably better demonstrated in the lordotic position than in any other projection. Frequently, sizable lung hernias

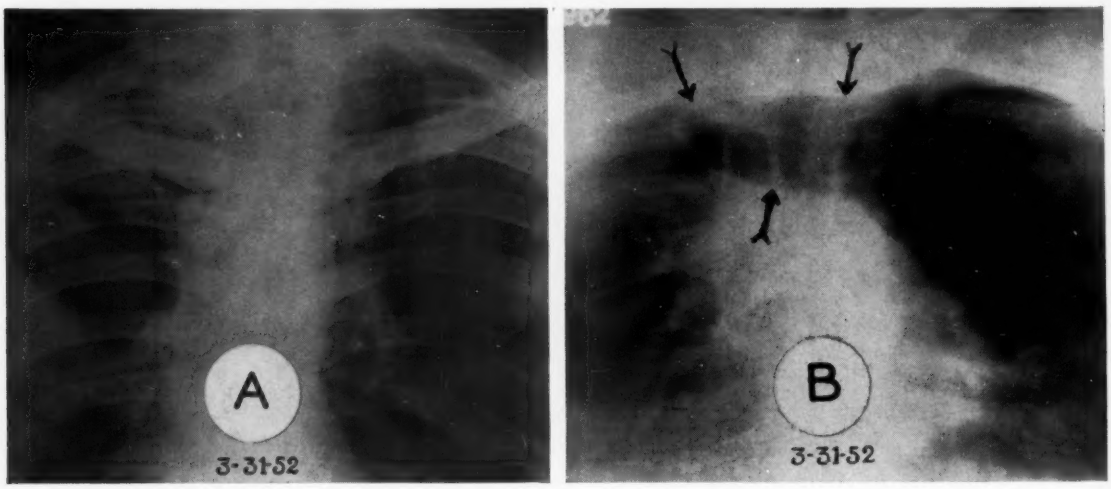

Fig. 4. (*A*) Posteroanterior. Evidence of anterior mediastinal lung hernia is not visible. (*B*) Lordotic. Large anterior mediastinal lung hernia is clearly outlined extending from left into right hemithorax. (Verified at autopsy in a number of other patients.)

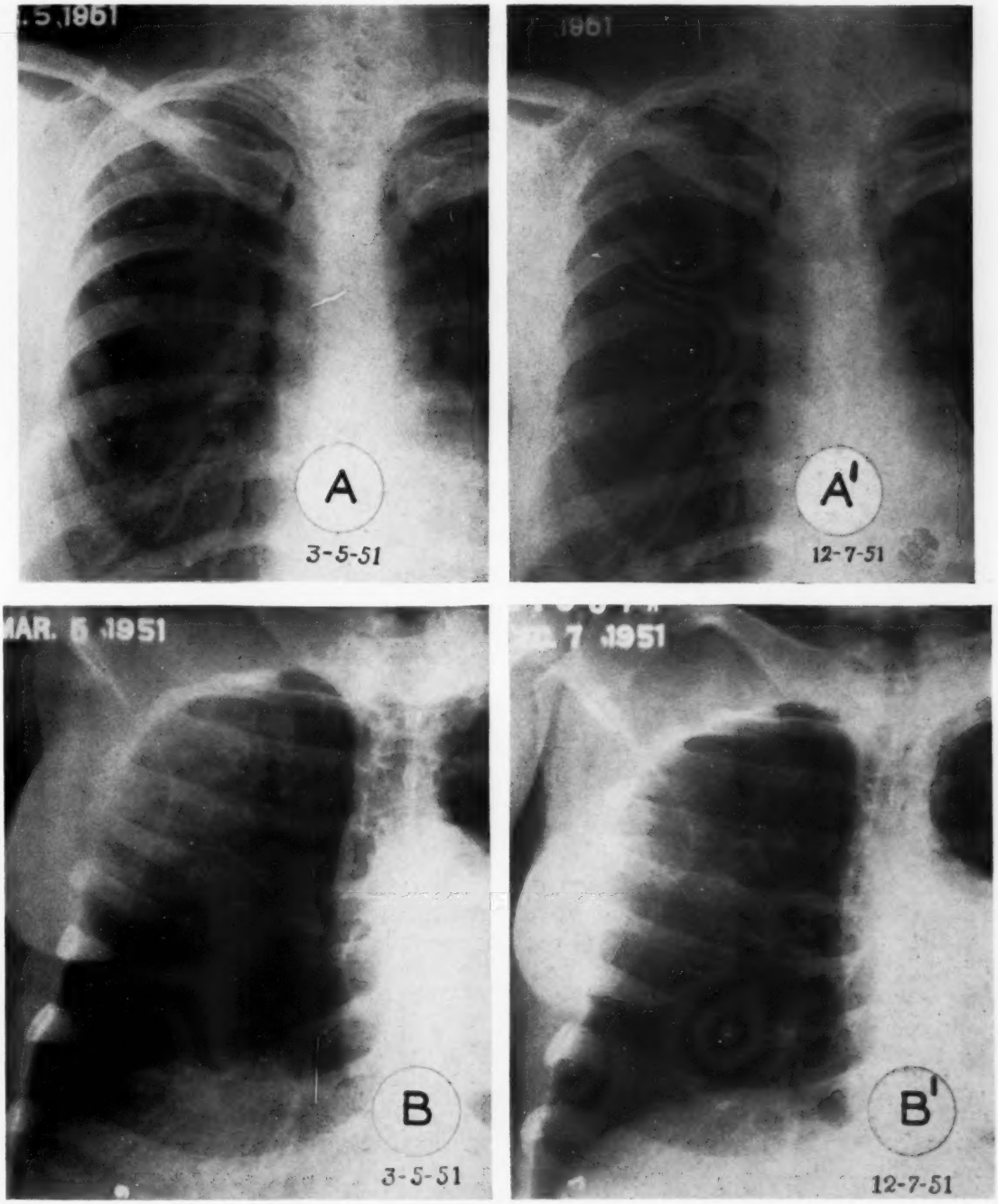

FIG. 5. (*A* and *A'*) Serial posteroanterior roentgenograms show probable slight clearing. (*B* and *B'*) Serial lordotic roentgenograms show definite moderate clearing.

will be demonstrated in the lordotic position (Fig. 4*B*) when no evidence of such is seen in the routine posteroanterior projection (Fig. 4*A*). Here the lordotic position possesses considerable advantage over the lateral or oblique views since in it the outline of the hernia is clearly visible and the distance it projects beyond the midline can be determined with reasonable accuracy (Fig. 4*B*), allowing for magnifica-

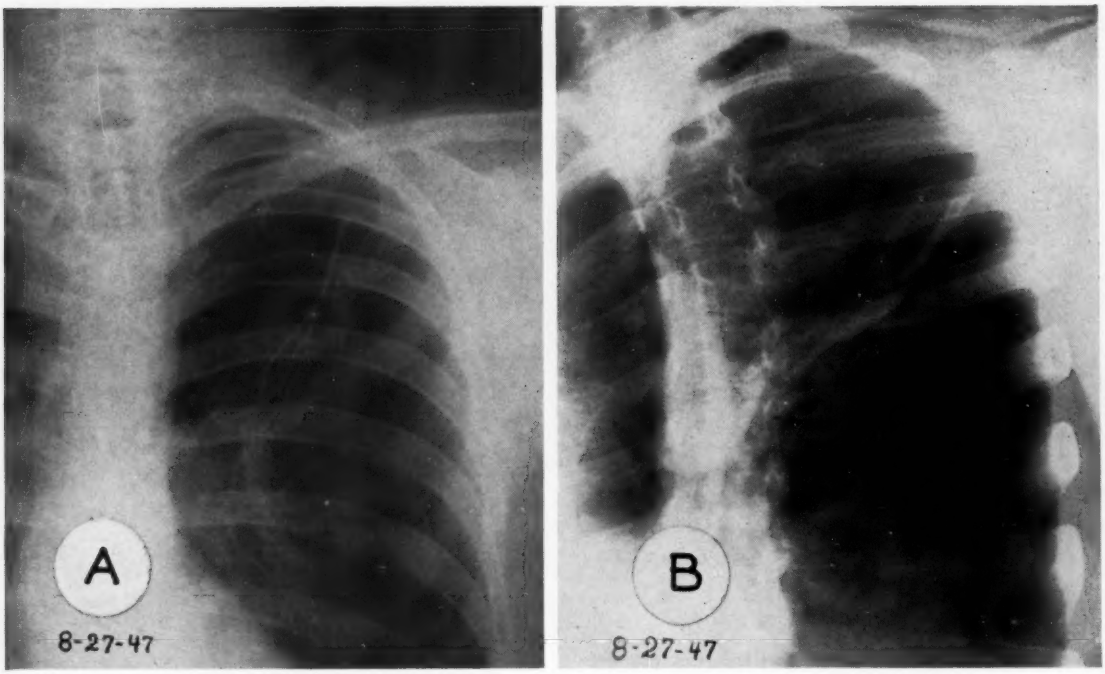

Fig. 6. (*A*) Posteroanterior. Shadow of adhesion is visible. (*B*) Right posterior oblique lordotic. Adhesion is localized to posterolateral portion of left chest.

tion. The presence of such hernias and their size and location are important facts, especially to those working in the field of thoracic diseases.

Not uncommonly, when one compares serial roentgenograms or fluoroscopic findings, the lordotic position (Fig. 5*B-B'*) will show a definite change for either better or worse (and this change may be of considerable magnitude), while the usual posteroanterior studies (Fig. 5*A-A'*) show no recognizable change, or, at most, a questionable change. It should be emphasized that for satisfactory comparison of any serial roentgen studies the positioning and roentgenologic technique must be practically identical.

In the presence of pneumothorax the lordotic position, including the oblique lordotic (Fig. 6*B*), will assist in the demonstration and localization of adhesions. It may show a sizable loculated pneumothorax (Fig. 7*B*), when in the usual posteroanterior position (Fig. 7*A*) lung markings extend practically out to the chest wall throughout the lung field with no visible evidence of pneumothorax. Similarly, it may demonstrate symphysis of the lung and upper anterior chest wall (Fig. 8*B*), when this cannot be seen in the usual posteroanterior position (Fig. 8*A*). And, at times, confusing shadows in the lung field (Fig. 9*A*) have been shown by the lordotic position (Fig. 9*B*) to be due to subcutaneous emphysema of the anterior chest wall.

The advantages of the lordotic position (Fig. 10*B*) over the conventional posteroanterior projection (Fig. 10*A*) in detecting collapse of one or both segments of the right middle lobe have been well described and illustrated by Robbins and Hale.[14] The appearance of collapse of the lingual segment of the left upper lobe is similar and, if looked for, will be not infrequently found, especially at fluoroscopy in the right anterior oblique lordotic position, and can be recorded on film on the left posterior oblique lordotic position.

We have found no mention in the literature of the advantages of the lordotic position in the detection of collapse of other lobes.

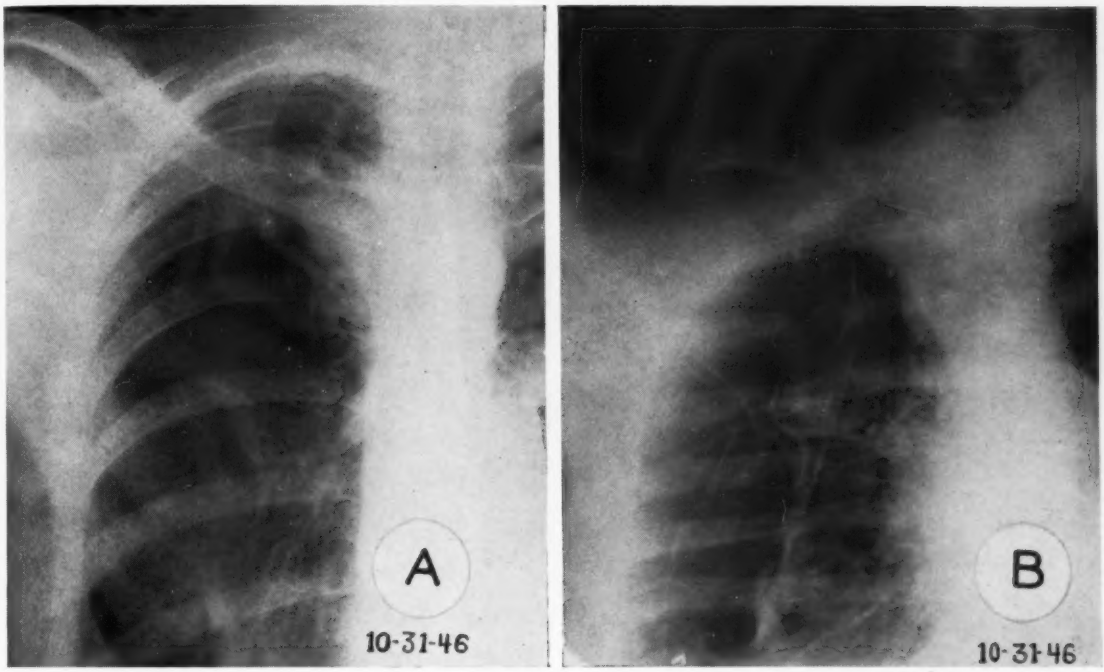

FIG. 7. (*A*) Posteroanterior. No visible evidence of pneumothorax. (*B*) Lordotic. Large loculated pneumothorax space in anterior portion of chest is demonstrated. (Compare with Figure 8.)

Signs of collapse of the right upper lobe are usually evident in the conventional posteroanterior projection. Fairly commonly, however, the evidence is inconclusive (Fig. 11*A*). This is apparently due to variations in the manner in which the

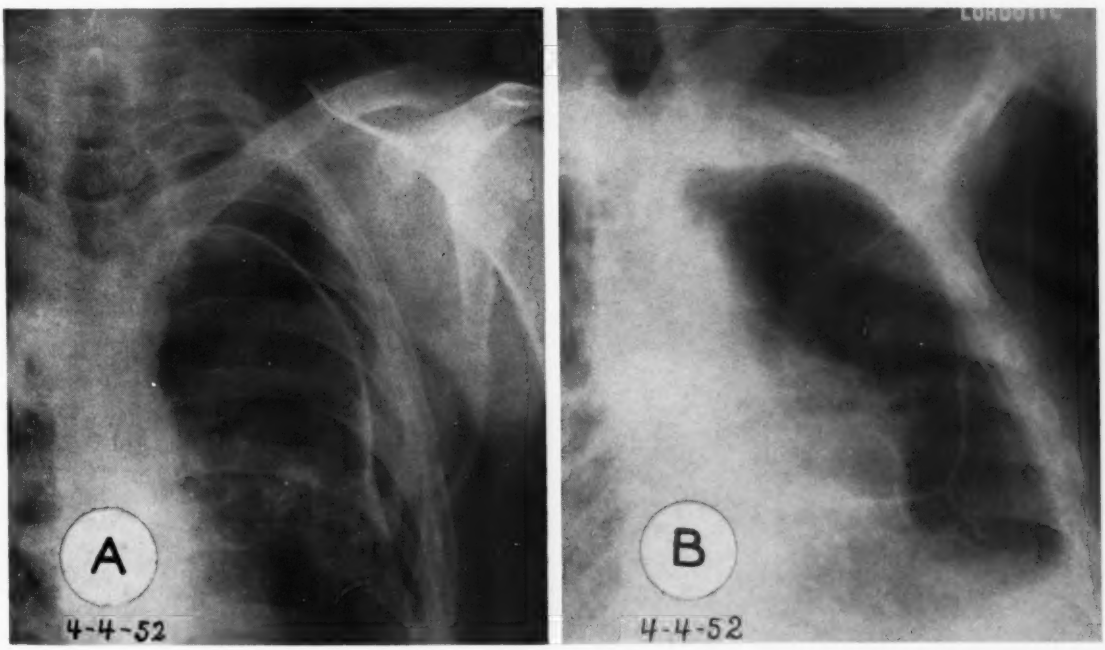

FIG. 8. (*A*) Posteroanterior. Evidence of pneumothorax visible with lung apparently free in upper two-thirds of chest. (*B*) Lordotic. Lung markings extend out to upper anterior chest wall indicating symphysis of lung and upper anterior chest wall. Study of Figure 21, *A* and *B* will make the reason for this apparent.

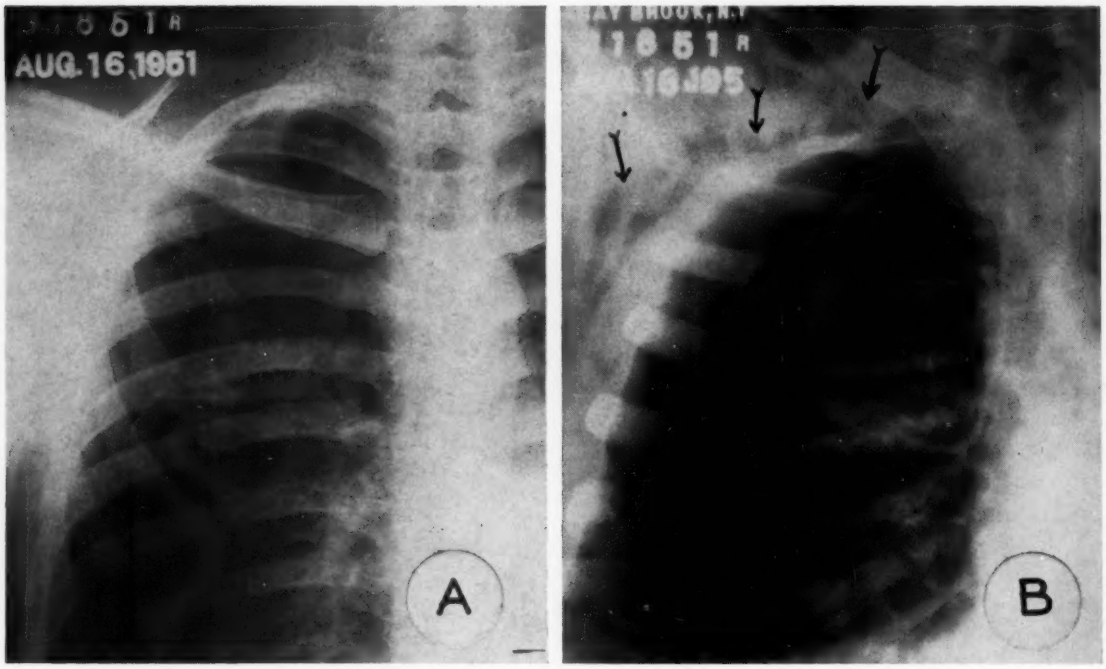

Fig. 9. (*A*) Posteroanterior. Confusing shadows in right upper hemithorax outside outline of lung partially collapsed by therapeutic pneumothorax. (*B*) Lordotic. Confusing shadows shown to be due to subcutaneous emphysema of anterior chest wall.

lobe collapses depending on the number, size and location of pleural adhesions and the amount and location of solid non-collapsible tissue present in the lobe. Here

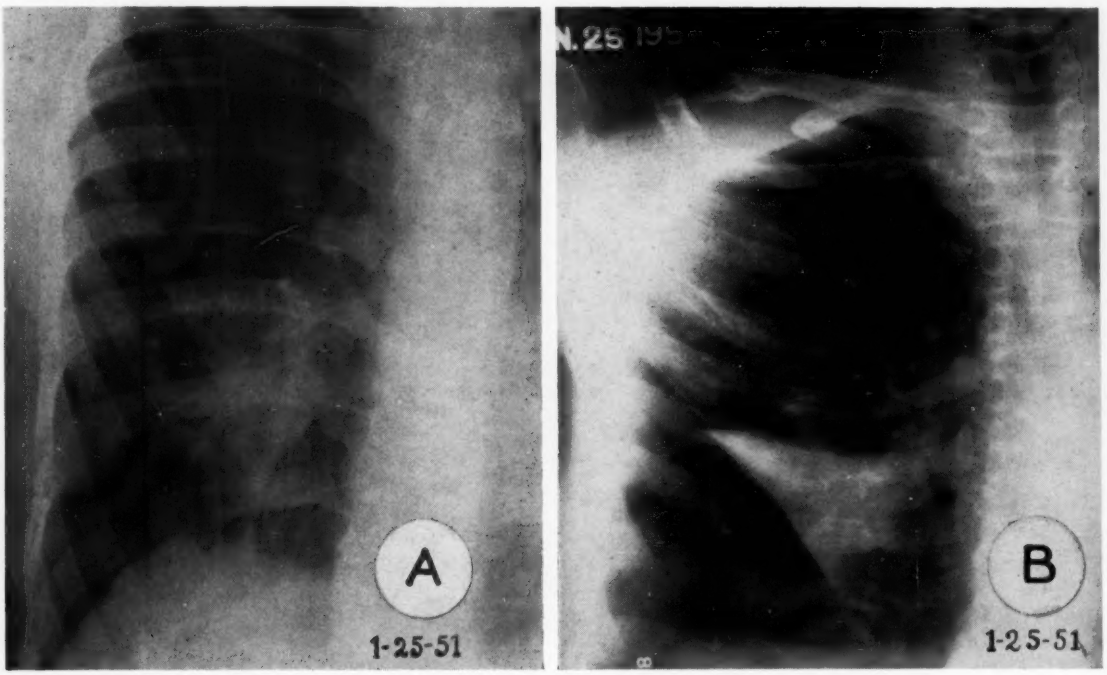

Fig. 10. (*A*) Posteroanterior. Abnormality in lower medial lung field; however, its nature is not obvious. (*B*) Lordotic. Typical roentgenographic appearance of collapse of lateral segment of right middle lobe.

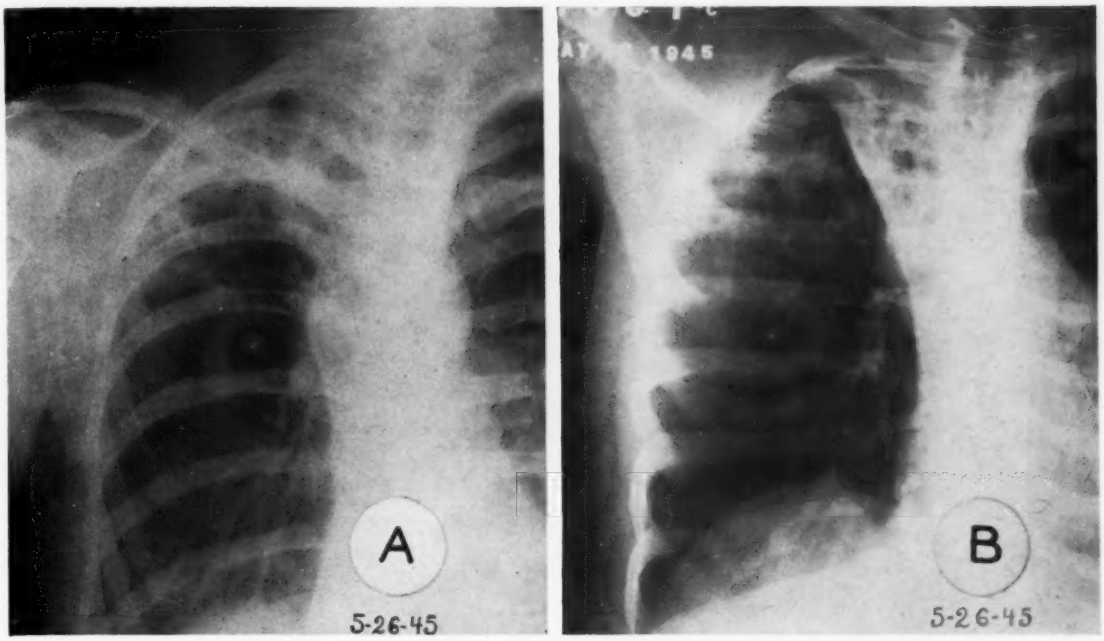

FIG. 11. (*A*) Posteroanterior. Collapse of the right upper lobe is not evident; the minor fissure line is not visible. (*B*) Lordotic. Collapse of the right upper lobe is clearly demonstrated.

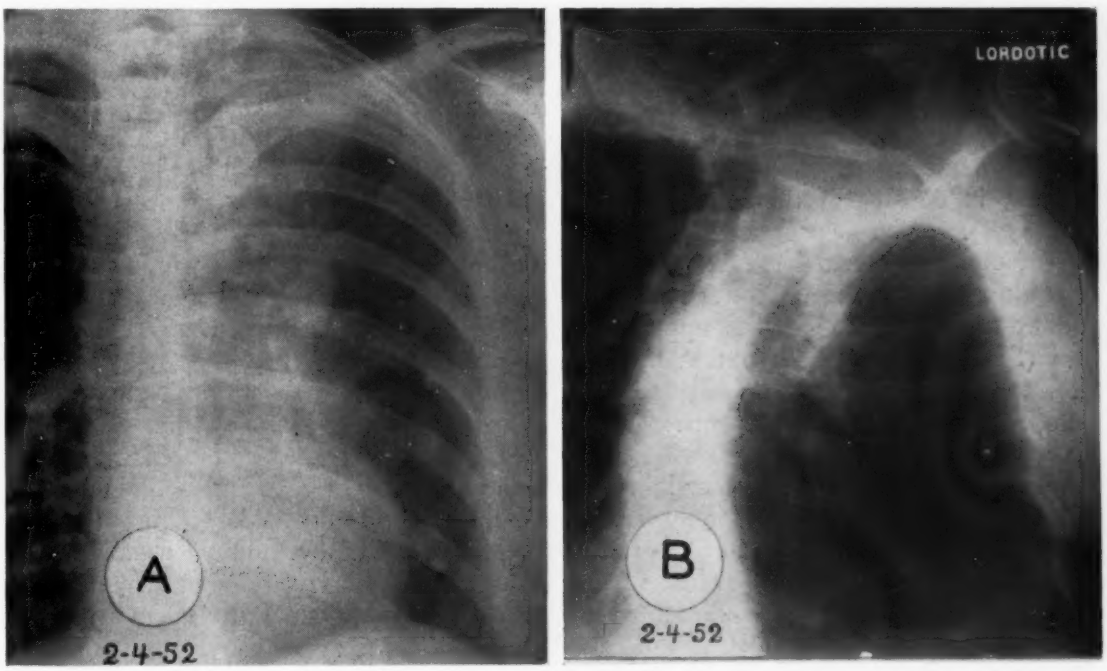

FIG. 12. (*A*) Posteroanterior. Diffuse increase in density of the left lung field is obvious but the reason for this is not evident. (*B*) Lordotic. The distribution of the density changes, becoming more marked in the upper lung field and less in the lower lung field. This indicates that the abnormality lies anteriorly and suggests collapse of the left upper lobe. Collapse of left upper lobe in this patient verified at operation. Refer also to Figure 21, *A* and *B*.

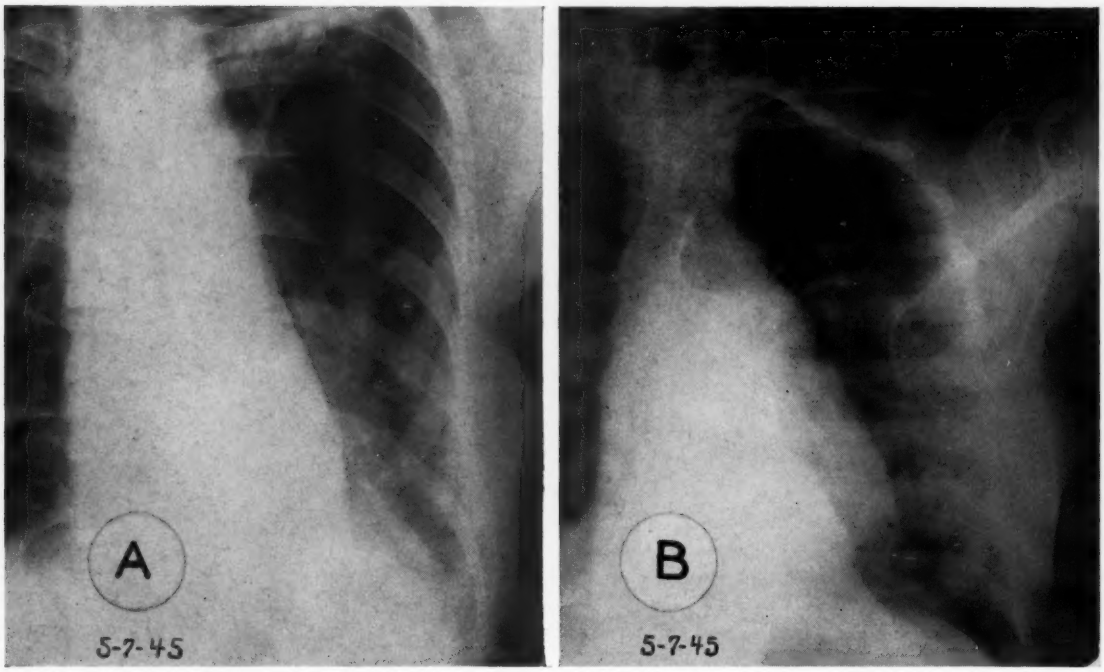

Fig. 13. (*A*) Posteroanterior. No evidence of collapse of left lower lobe. (*B*) Lordotic. Typical triangular density of collapsed left lower lobe is visible through the heart shadow.

the lordotic position will frequently demonstrate the collapsed right upper lobe (Fig. 11*B*).

Collapse of the entire left upper lobe causes, in the conventional posteroanterior projection, a fairly diffuse but not uniform increase in density of the left lung field (Fig. 12*A*). In the lordotic film the distribution of the abnormal density changes, becoming less dense in the lower lung field and much more dense in the upper lung field (Fig. 12*B*). In this situation the left lateral projection often demonstrates the collapsed upper lobe more convincingly than the lordotic.

With collapse of the left lower lobe the triangular density formed is often more or less obscured in the conventional posteroanterior position (Fig. 13*A*) by the superimposed heart shadow. While an overpenetrated Bucky roentgenogram will usually show the true state of affairs, the lordotic position will do just as well and sometimes better as in the case illustrated (Fig. 13*B*). In this patient the outline of the collapsed lower lobe was not visible in the overpenetrated Bucky posteroanterior roentgenogram since it coincided with the left border of the heart shadow. In our experience either the right or left oblique projections will usually show collapse of a lower lobe, but as mentioned above, the findings at preliminary fluoroscopy will determine which oblique and what degree of rotation will best demonstrate this abnormality. Lateral roentgenograms have rarely demonstrated convincing evidence of this situation.

Enlargement of the thyroid gland, particularly when there is some substernal extension of the gland, commonly results in an abnormal density in the medial portions of the apical lung fields (Fig. 14*A*); the density is fairly uniform, usually with sharply defined lateral borders, and is widest at the level of the extreme apical lung fields; its symmetry, or asymmetry, will depend on the shape and position of the goiter. In the lordotic position the abnormal density remains in close relation to the upper anterior chest wall. This serves to localize the abnormality and

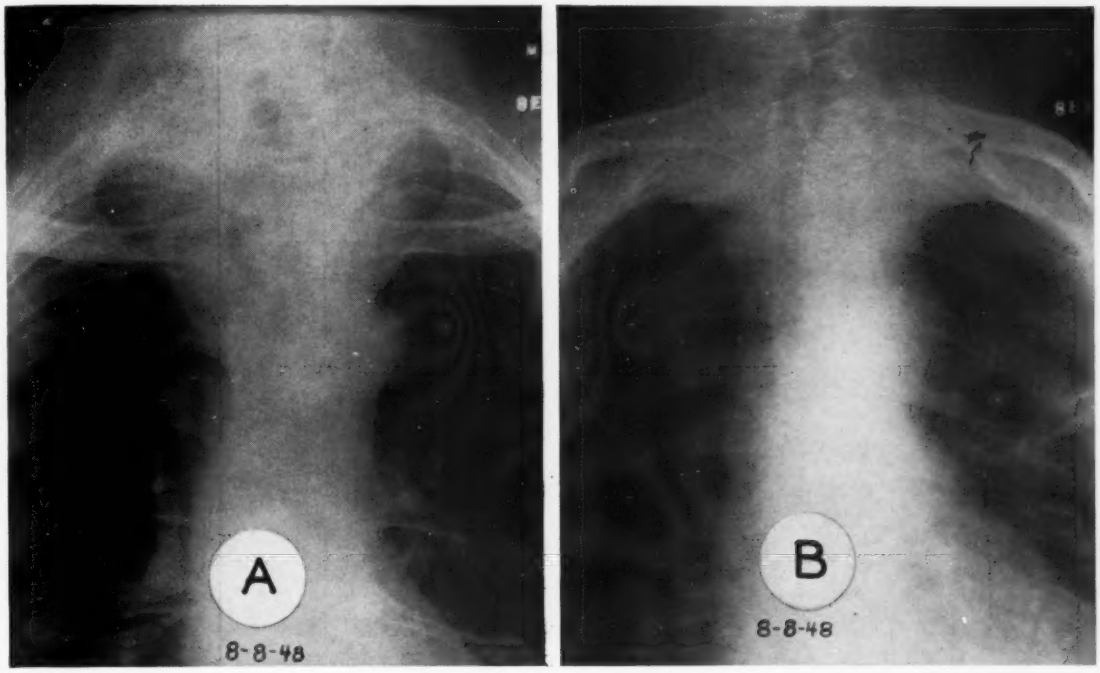

FIG. 14. (*A*) Posteroanterior. Abnormal hazy density in the medial portion of both apices. (*B*) Lordotic. The abnormal densities shift considerably in relation to the posterior segments of the ribs but shift little in relation to the bony structures of the anterior chest wall. This localizes the abnormality to the anterior chest and neck and suggests enlargement of the thyroid gland with substernal extension.

suggests its nature (Fig. 14*B*). At fluoroscopy, when the patient swallows or coughs, the abnormal shadow moves sharply cephalad, then returns more slowly to its "resting" position. If there is tracheal compression, this is strikingly shown with the patient in the usual or in the right or left oblique lordotic position, especially when an overpenetrated technique is used.

The appearance of enlargement of the outflow tract of the right ventricle and the pulmonary artery as seen in the lordotic position (Fig. 15*B*), versus the routine posteroanterior projection (Fig. 15*A*), have been well described and illustrated by Cole.[3]

The major or oblique fissure lines are often clearly seen in the lordotic since, in this position, these fissures are more or less parallel to the roentgen rays. Hence, interlobar effusions in the oblique fissures will be demonstrated by the lordotic (Fig. 16*B*) and not by the routine posteroanterior film (Fig. 16*A*). Examination in the oblique or lateral projection often gives confirmatory evidence.

Although several of the earlier writers[5,9,12,15,16,17] used the lordotic position for the express purpose of demonstrating interlobar effusions, a review of the illustrations in their papers suggests that the abnormalities, ascribed to "interlobar effusions," were for the most part actually due to collapse of either the medial segment or the whole of the right middle lobe. At least one of these writers[10] is, at present, of this same opinion.

The lordotic position has also proved of value in various other situations. It has demonstrated that what appeared to be calcified foci in the lung on the conventional posteroanterior film (Fig. 17*A*) were actually calcified cervical, supraclavicular or infraclavicular lymph nodes (Fig. 17*B*). It, together with the routine posteroanterior film, has shown that a metallic foreign body was located in the soft tissues of the anterior chest wall and not in the

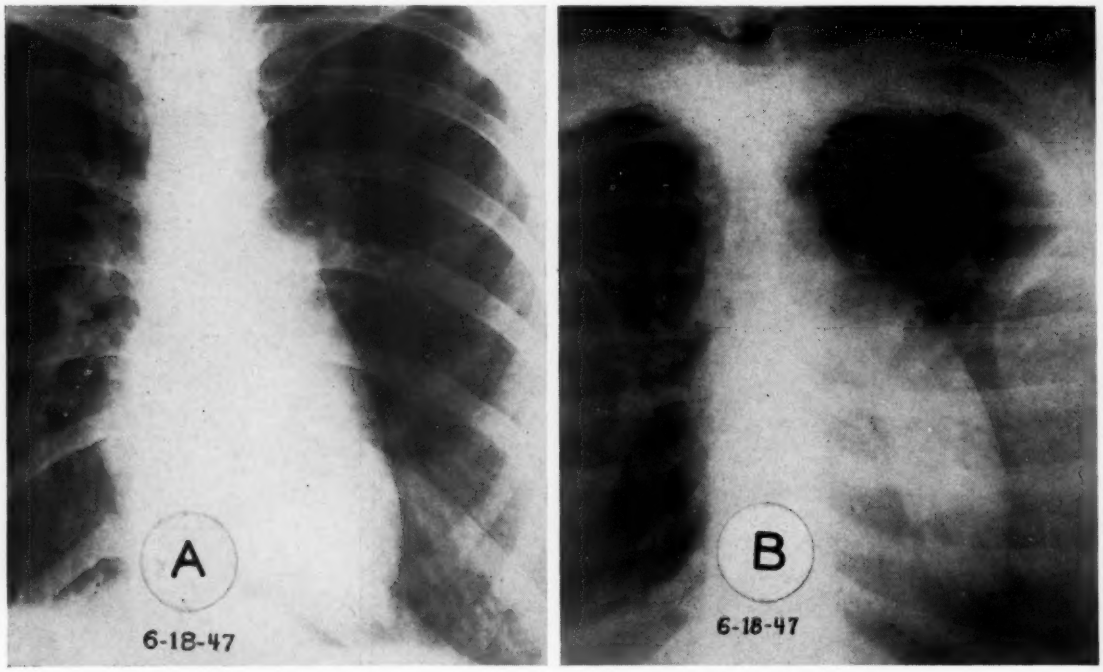

Fig. 15. (*A*) Posteroanterior. Slight prominence of pulmonary artery segment of heart shadow. (*B*) Lordotic. Marked prominence of heart shadow in region of pulmonary conus and pulmonary artery. The abnormal convexity of the left border of the heart shadow becomes more evident if this figure is compared with Figure 14.

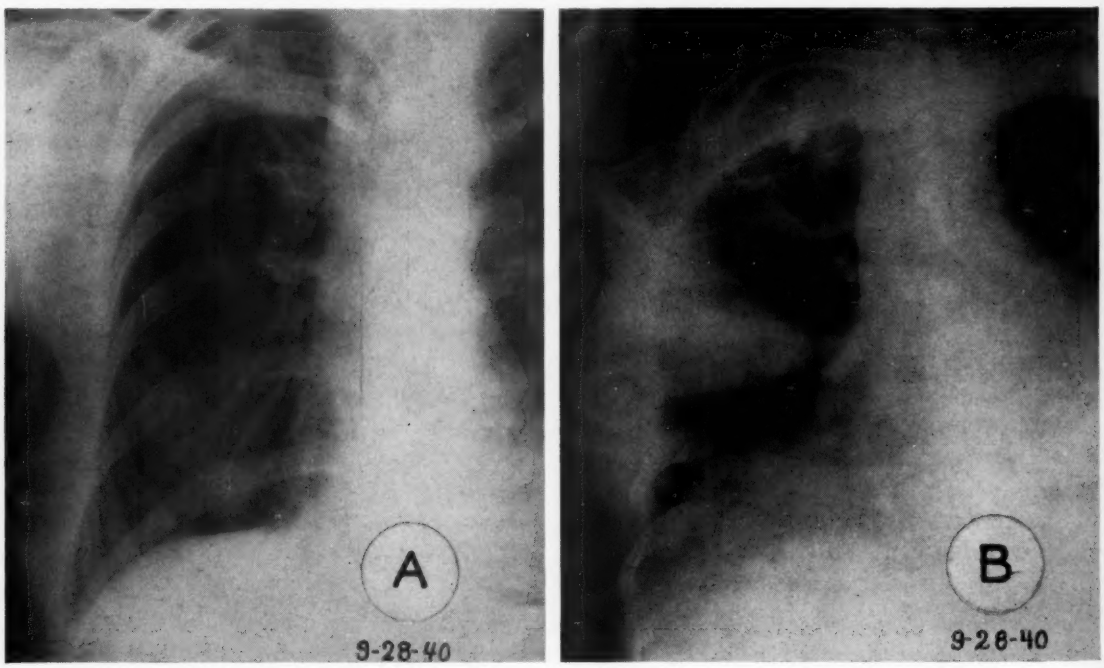

Fig. 16. (*A*) Posteroanterior. Diffuse, very poorly defined, cloudy density in lower right lung field. (*B*) Lordotic. Typical appearance of interlobar effusion—sharply defined somewhat fusiform shaped density in region of major fissure.

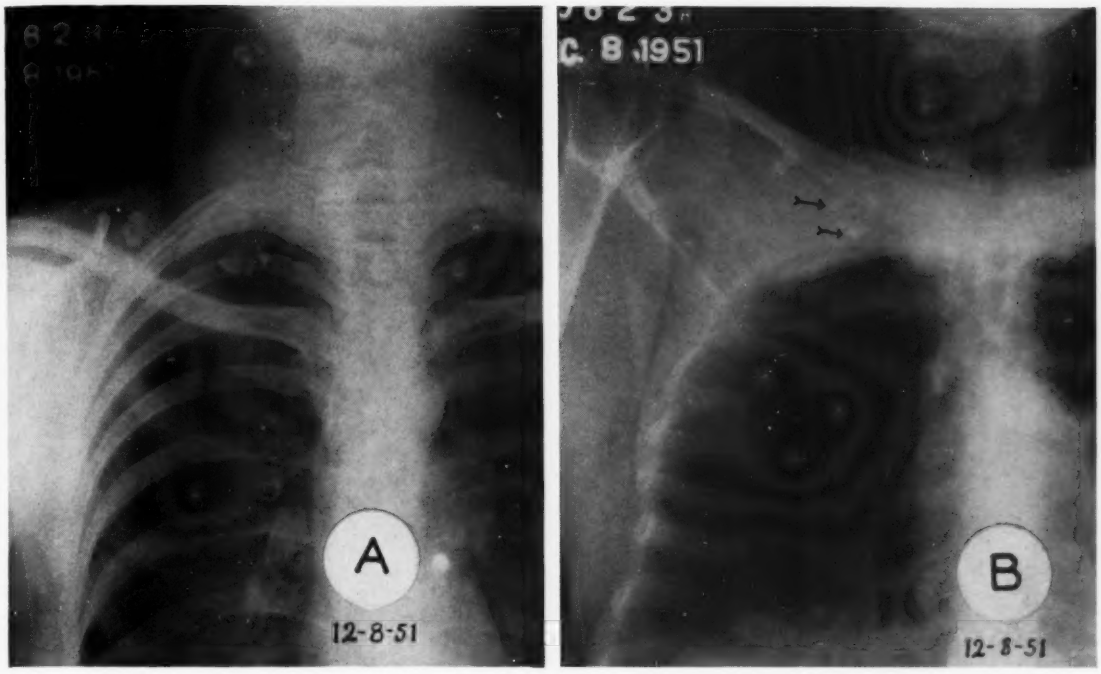

FIG. 17. (*A*) Posteroanterior. Calcified foci apparently in apex of lung. (*B*) Lordotic. Calcific densities now lie outside the bony thoracic cage indicating that they represent calcified cervical or supraclavicular lymph nodes.

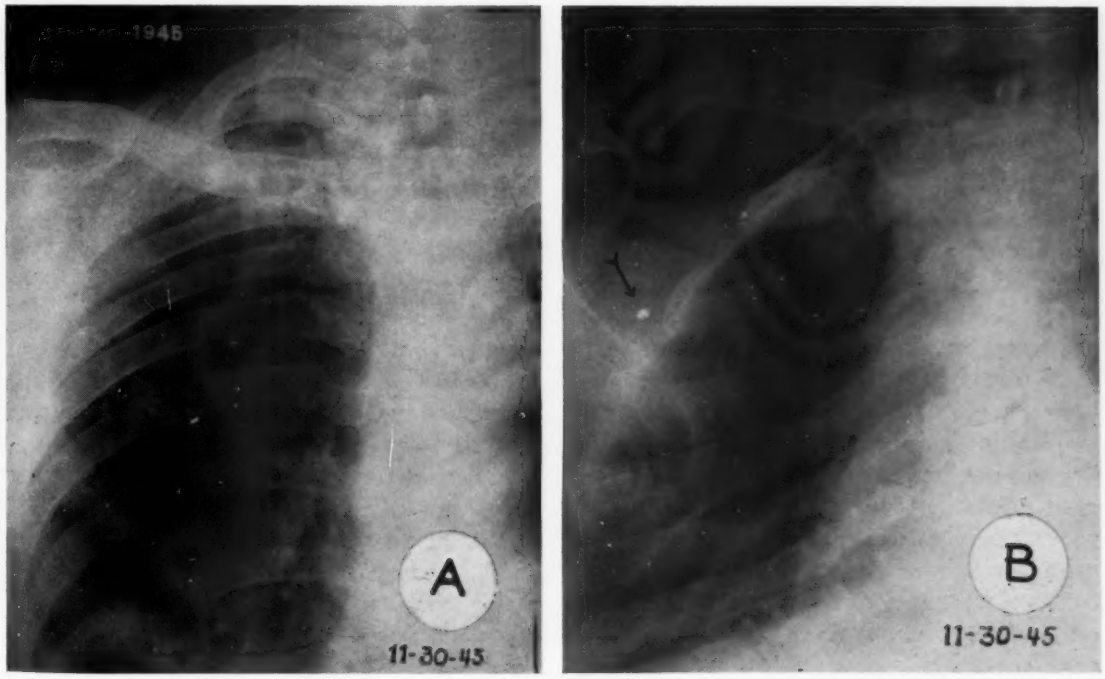

FIG. 18. (*A*) Posteroanterior. Shadow of metallic foreign body overlies mid lung field. (*B*) Lordotic. Shadow of foreign body now lies outside bony thoracic cage showing that the foreign body is in the soft tissues of the anterior chest wall instead of the lung or the posterior chest wall.

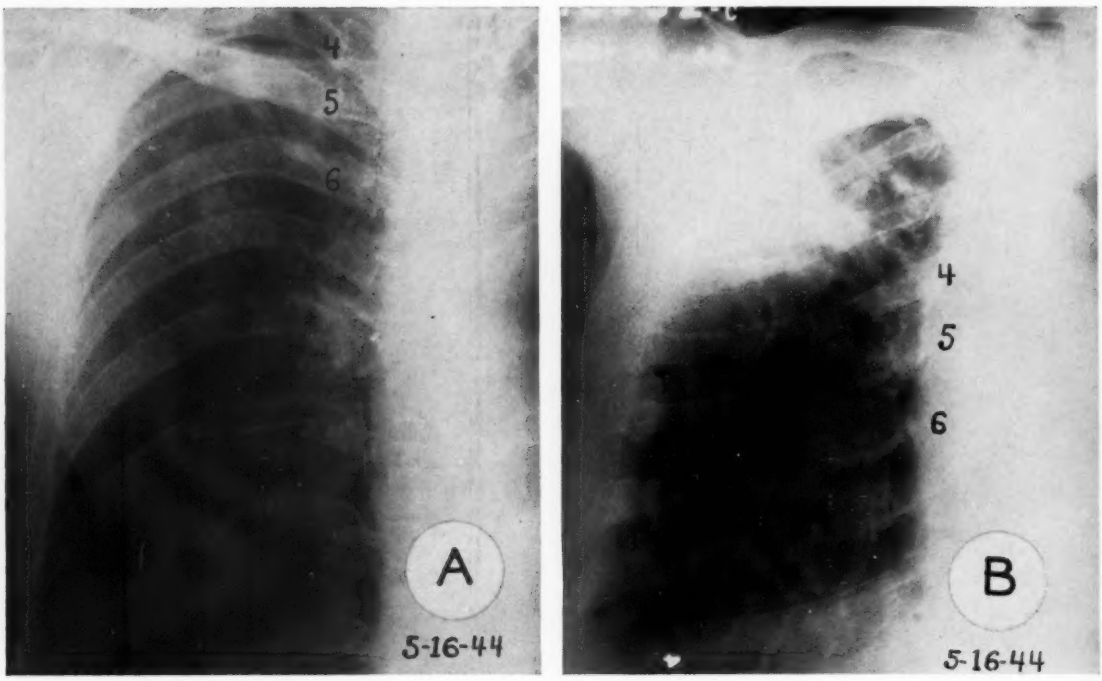

Fig. 19. (*A*) Posteroanterior. No evidence of rib fractures visible. (*B*) Lordotic. Fractures of three ribs with callus formation is clearly visible.

lung or posteror chest wall (Fig. 18*A* and *B*). Cervical ribs and evidence of funnel chest are usually well seen in the lordotic and this position has shown evidence of multiple rib fractures (Fig. 19*B*) not visible in the conventional posteroanterior roentgenogram (Fig. 19*A*). Detail in the posterior segments of the upper ribs is better than in the posteroanterior view and in the examination of the upper dorsal and lower cervical spine, the overlapping of adjacent vertebral bodies in the usual projection is largely eliminated by the lordotic position.

The lordotic position also assists in "ruling out" disease. Anatomic variations, especially when unilateral or irregular, such as unusually deep supraclavicular and infraclavicular depressions, calcified first costal cartilages, or prominent rhomboid fossae in the clavicles, will often produce confusing shadows which may be considered evidence of disease. The difficulties in interpretation produced by these anatomic variations are readily resolved by the lordotic position, especially at fluoroscopy in the oblique positions.

Roentgenological study made in both the lordotic and the conventional posteroanterior positions, which in effect allows examination from two widely different view points, makes possible fairly accurate localization of any object whose shadow is visible in both projections. Such localization, being but a practical application of elementary geometry, is easy and depends upon the change in position of the shadow of the object in relation to the shadows of the anterior and posterior segments of the ribs in the two projections. For example, when the patient is changed from the usual posteroanterior position (Fig. 20*A*) to the lordotic (Fig. 20*B*) or vice versa, the shadow of any object located in the posterior portion of the chest (Fig. 20*A* and *B*) will move little in relation to the shadows of the posterior segments of the ribs; contrariwise the shadow of the posteriorly located object will move much in relation to the shadows of the anterior

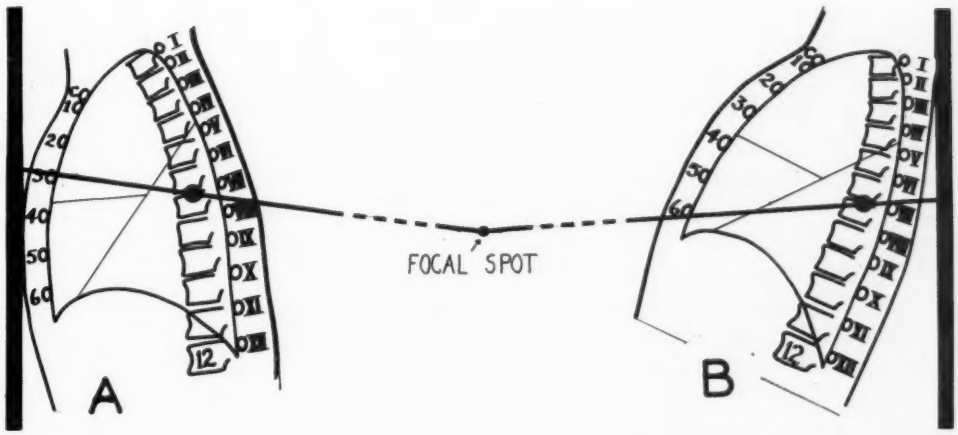

FIG. 20. Diagram to illustrate the principles of localization using both posteroanterior and lordotic projections. In this (and in Figure 21) the small open circles represent the clavicle and ribs while Arabic numerals (1, 2, 3, etc.) indicate the anterior segments of the ribs, Roman numerals the posterior segments, *C* the clavicle, and the black circle a lesion. (*A*) Posteroanterior. With a lesion in the posterior portion of the lung, as indicated, its shadow on the roentgenogram or fluoroscopic screen will lie in close relation to the shadows of rib 3 anteriorly and rib VII posteriorly. (*B*) Lordotic. The shadow of the lesion which is posterior remains in close relation to the shadow of rib VII posteriorly but shifts markedly in relation to the shadow of rib 3 anteriorly. Therefore, if the position of a lesion is unknown, and its shadow shifts little in relation to the posterior segments of the ribs but much in relation to the anterior segments of the ribs when the patients is changed from the conventional posteroanterior to the lordotic position, or vice versa, the lesion must be in the posterior portion of the lung.

segments of the ribs. The converse is true of the shadow of any object located in the anterior portion of the chest (Fig. 21*A* and *B*). When an object is midway between the anterior and posterior chest walls, its shadow will move about the same distance in relation to the shadows of both the anterior and posterior segments of the ribs.

On comparing the routine posteroanterior and the lordotic pair of films, or fluoroscopic screen images, the amount of motion that any object's shadow makes with relation to any other object's superimposed shadow in either projection is directly proportional to the distance between the two objects in the other projection. This is true either on roentgenograms or on the fluoroscopic screen. One outstanding advantage of fluoroscopy is that, unless two or more structures are in immediate juxtaposition, superimposition can be readily eliminated by rotating the patient or by having him inhale or exhale whether he be in the upright posteroanterior, lordotic, oblique or lateral position. Precise localization of any structure, normal or abnormal, which is visible in multiple projections on either the fluoroscopic screen or roentgenograms is extremely simple. However, a discussion of roentgenologic localization, except in relation to the lordotic routine posteroanterior pair of films or screen images is outside the scope of this paper. It must be emphasized that the experience of fifteen years of teaching this to both undergraduate and postgraduate students has abundantly proved that, *on first attempt*, the grasp of the simple, fundamental principles of roentgenologic localization of any structure in the thorax has uniformly proved to be very difficult or impossible. However, if repeated attempts are made employing cross section sketches or diagrams (as in Fig. 20*A* and *B* and Fig. 21*A* and *B*) of the three planes of the chest the principles become simple and clear.

At times, examination in the lordotic position fails to show evidence of disease

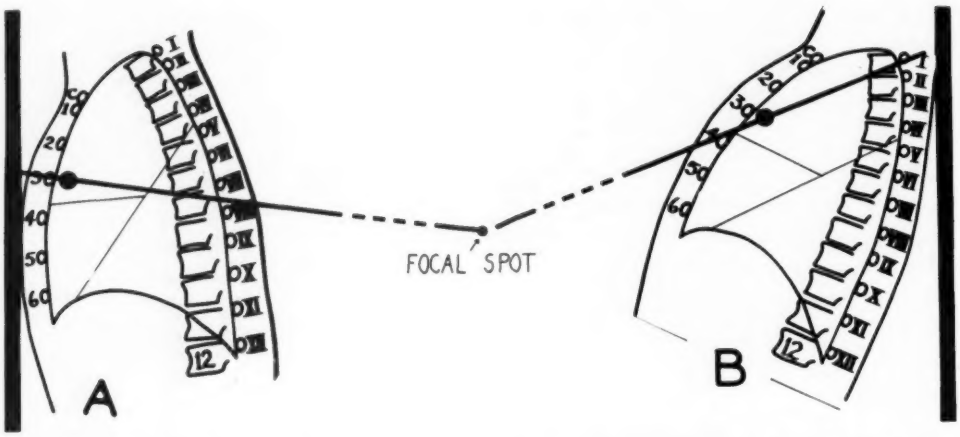

Fig. 21. Diagram to illustrate the principles of localization using both posteroanterior and lordotic projections. (*A*) Posteroanterior. With a lesion in the anterior portion of the lung, as indicated, its shadow on the roentgenogram or fluoroscopic screen will lie in close relation to the shadows of rib 3 anteriorly and rib VII posteriorly as in Figure 20. However, when the patient is changed to the lordotic position (*B*) the shadow of the lesion which is anterior remains in close relation to the shadow of rib 3 anteriorly but shifts markedly in relation to the shadow of rib VII posteriorly. Therefore, if the position of a lesion is unknown, and its shadow shifts little in relation to the anterior segments of the ribs but much in relation to the posterior segments of the ribs when the patient is changed from the conventional posteroanterior to the lordotic position, or vice versa, the lesion must be in the anterior portion of the lung. (Localization is also illustrated by figures 6, 7, 10, 12, 14, 17, and 18.)

when study in the conventional posteroanterior projection reveals unmistakable abnormalities. This may be due to one or more of several possibilities. Chance superimposition of the shadow cast by a small abnormality upon that cast by bony, vascular, or soft tissue structures may occur, preventing recognition of the ab-

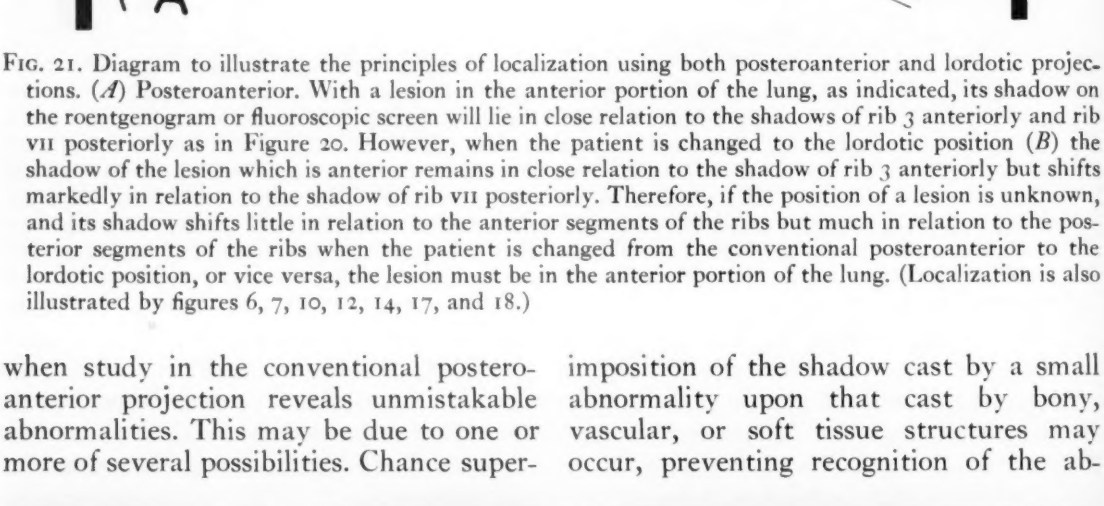

Fig. 22. (*A*) Posteroanterior. Evidence of small amount of disease in the left upper third; none on right. No visible nipple shadows. (*B*) Lordotic. Nodular density in the middle third of the right lung field and much less well defined similar density in the left lung field. These are asymmetrical nipple shadows. Note how much higher in the lung fields they are than we are accustomed to seeing them in the conventional posteroanterior roentgenogram.

normality in the lordotic position. Likewise, chance superimposition or lining up, in the posteroanterior projection but not in the lordotic position, of two or more "subvisible" abnormalities may allow recognition of disease only in the former. Further, a "pancake" shaped density with its long diameter extending anteroposteriorly and being horizontal in the posteroanterior position may be demonstrated by the posteroanterior but not the lordotic position.

Nipple shadows seen in the lordotic film are at times confusing, especially if the nipples are long and horizontal and the breasts small. This is, of course, more common in women than in men but does occur in the latter. The nipple shadows will appear as nodular densities much higher in the lung field in the lordotic position (Fig. 22*B*) than we are accustomed to seeing them on the conventional posteroanterior film and may be mistaken for nodular areas of disease, especially if only one is visible or if they are asymmetrical. At fluoroscopy, by rotation of the patient from side to side or by having the patient manually move the breast or nipple, the image on the screen can be readily identified.

When the range of motion of the spine is limited by stiffness or pain or when the thorax has a very small anteroposterior diameter, it is often difficult or impossible to obtain a satisfactory lordotic roentgenogram using the technique described below.

In our experience, the routine posteroanterior film plus a lordotic roentgenogram give much more information concerning the thorax than do conventional stereoscopic roentgenograms. Even though the time needed for the technician to take the posteroanterior and lordotic pair of films exceeds that for the stereoscopic roentgenograms, the additional information obtained more than justifies the extra time and effort on the part of the technician. As a result, stereoscopic films are rarely requested in this hospital.

The technique of obtaining a satisfactory lordotic roentgenogram is not difficult but here, as in all roentgen procedures, strict attention to detail is all important. It should be pointed out that in fluoroscoping a patient in the lordotic position, the examination is done in the posteroanterior projection while the lordotic roentgenogram is exposed in the anteroposterior projection; this solely because of the greater ease of positioning the patient with his back against a firm support—the tabletop in fluoroscopy, the cassette changer or tabletop in roentgenography. This difference in projection results in some variation between the image on the fluoroscopic screen and that in the lordotic roentgenogram. Because of the divergence of the rays the shadows of the scapulae can readily be eliminated from the lung fields at fluoroscopy (in the posteroanterior projection) while at roentgenography (in the anteroposterior projection) the shadows of the scapulae always overlie the lung fields to some extent, this being determined largely by the proper instruction of and cooperation by the patient. It is obvious that positioning of the patient is of paramount importance in obtaining a satisfactory lordotic roentgenogram.

We have found that the routine use of the Bucky diaphragm results in better lordotic films. Either a cassette changer equipped with a Bucky diaphragm or the Bucky diaphragm in a tilting roentgenographic table in the vertical position may be used. Equipment is so arranged that a 48 inch focal spot-film distance can be obtained. An 11 by 14 inch film is routinely used with the long dimension horizontal.

The patient stands with his back toward the vertical tabletop or cassette changer, his feet one short step away from the base of the table. He then leans back, with the spine well arched forward so that the uppermost dorsal part of the chest and not the head touches the table and supports the weight of the upper part of the body. The neck muscles should be relaxed; the legs should be extended, as far as comfortably possible, at the knees. The relation of the thorax to the tabletop for the usual lordotic position should be about a 45°

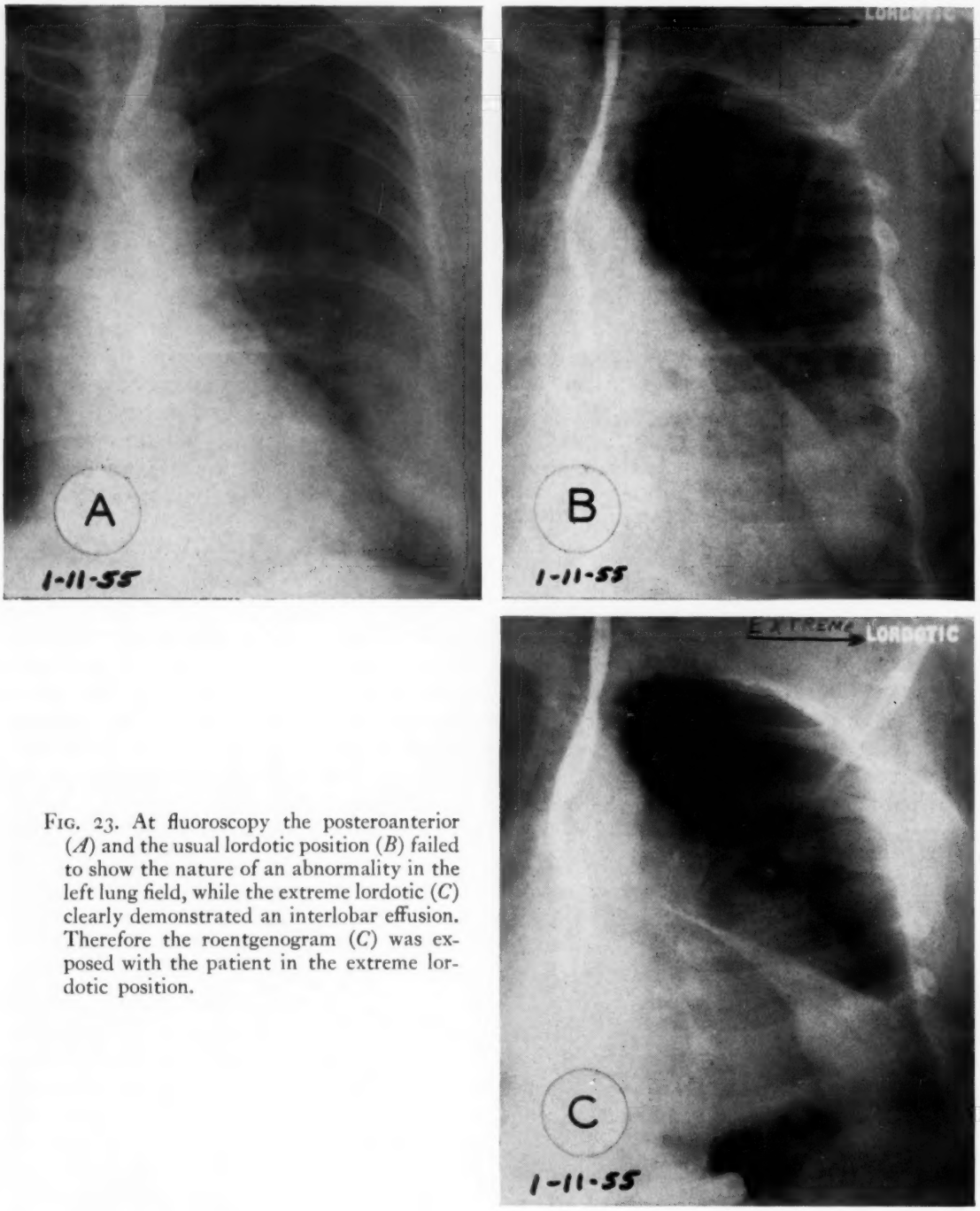

Fig. 23. At fluoroscopy the posteroanterior (*A*) and the usual lordotic position (*B*) failed to show the nature of an abnormality in the left lung field, while the extreme lordotic (*C*) clearly demonstrated an interlobar effusion. Therefore the roentgenogram (*C*) was exposed with the patient in the extreme lordotic position.

angle, although this will vary depending upon the patient's build and on the findings at preliminary fluoroscopy. There are times when less tilt than is necessary to eliminate the clavicles from the lung fields will demonstrate a particular abnormality best and there are other instances when more tilt (extreme lordotic position, Fig. 23*C*) will demonstrate the abnormality best.

At this point the patient's arms should be hanging loosely at his sides. He is

cautioned against straightening up or sliding his chest up on the tabletop and is instructed to hunch his shoulders forward as far as he can (sliding the scapulae laterally over the chest wall) and at the same time to elevate his shoulders as much as possible (to rotate the scapulae on the chest wall, moving their angles even further laterally). These two movements serve to eliminate as far as possible the images of the scapulae from the lung fields. The arms are still dangling but held a little away from the sides of the body. If the patient is permitted to put the backs of the hands on the hips, buttocks, or thighs, this interferes with the movements of the shoulder girdle to some extent and the scapular shadows will not be as far out of the lung fields as is possible. Further, if the patient is permitted to put his hands on his hips the images of the hands will commonly partially obscure the lower lung fields.

A focal spot-film distance of 48 inches is used, the focal spot level about 1 inch below the xiphoid cartilage. The film is ordinarily exposed during maximum inspiration, the patient again being cautioned to maintain his position, since there is a tendency to slide up on the table with deep inspiration. A bit of coaching is frequently necessary but the small amount of time taken is well spent. Since the lordotic position is rather awkward and difficult to hold for a long period, the control panel should be set up and everything possible arranged before the positioning of the patient.

For the average sized adult the exposure factors (Bucky) are: 200 ma., 0.1 second, 90 to 94 kv. peak. Depending on the size of the patient, the extremes are 86 to 98 kv. peak and 0.1 to 0.2 second. Films are developed by inspection and development time is about one and one half minutes at 68°F. The normal full development time for the developer which we use is three minutes. In our hands the routine use of a technique employing intentional overexposure and underdevelopment has uniformly produced the most satisfactory films. The greatest visibility of detail is obtained when the finished roentgenogram is soft, with a long gray scale and no dense black or too clear areas. Such a film will result from this technique.

Where a Bucky diaphragm is not available, the following technique will be found fairly satisfactory: For a given patient use the same milliamperage, kilovoltage and exposure time as in taking a regular posteroanterior chest film but decrease the focal spot-film distance from 72 to 48 inches.

SUMMARY

The additional information obtained by employing the lordotic position in both fluoroscopic and roentgenographic examinations of the chest warrants its more general and frequent use.

Examination of the patient in the lordotic position allows a more thorough study not only of the upper part of the chest but also of the middle and lower thirds and added information is gained concerning the lungs, bronchi, pleurae, heart, great vessels, chest wall, and even the cervical structures.

The several situations in which this position gives added information concerning the chest are described and roentgenograms are presented which demonstrate its value.

The fundamentals of localization using the posteroanterior and lordotic pair of roentgenograms or fluoroscopic screen images, are outlined and illustrated.

The few limitations of this supplementary position are listed.

Both the positioning and the roentgenographic techniques, which are simple and easily learned, are described.

In our experience, the routine posteroanterior film plus a lordotic give much more information concerning the chest than do conventional stereoscopic roentgenograms.

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THE CURRENT STATUS OF BRONCHOGRAPHY WITH WATER-SOLUBLE MEDIA*

A REPORT OF 74 EXAMINATIONS WITH "XUMBRADIL VISCOUS B"†

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THE first report on successful use of water-soluble contrast medium for bronchography was published by Morales and Heiwinkel[40] of Sweden in 1948. Later during the same year, Fischer[15] reported his experience with a similar medium in Switzerland. Since the publication of these reports, numerous papers on the use of water-soluble contrast media for bronchography have appeared in the medical literature of Europe and the United States. Surprisingly, very few papers on this subject have been published in the radiological journals of this country. The simultaneous appearance of a variety of water-soluble contrast media with no significant difference in their actual chemical components but with different confusing trade names has been, perhaps, a major factor in the reluctance of radiologists to use these media. In this paper we will attempt to present some of the known information about the various new bronchographic media which have had clinical and laboratory trials in this country and Europe.

A BRIEF HISTORICAL REVIEW

Notwithstanding the popularity enjoyed by iodized oil for three decades, evidence has accumulated to indicate that this medium was responsible for a variety of local and systemic untoward reactions when used for bronchography. The most serious of these reactions has been the production of a long standing chronic inflammatory process, the so-called iodized oil granuloma which has been brought to focus recently by Fischer[16] and Felton.[14] In addition to this important complication, the use of lipiodol and other slow absorbing oil containing contrast media has other disadvantages which have been recognized by clinical investigators ever since they have been used in bronchography.[2,19,43] In 1931, Lenarduzi and Olper[56] used uroselectan in experimental bronchography. Later, in 1935, Anton[56] added an old-gum-foam to the same medium in order to prevent fast alveolarization of the contrast substance which was observed when the uroselectan was used alone. During the same year, Taylor and Bobrowitz[58] used a 35 per cent diodrast solution for bronchography, but because of the low viscosity of this medium marked alveolar filling occurred with resultant inadequate visualization of the bronchial tree. Subsequent attempts in making the available urographic contrast materials more viscous by the addition of gum arabic, pectin, gum tragacanth, polyethylene glycol, and polyvinyl-alcohol were unsuccessful.[56] Titus, Tafel, McCullan and Messer[59] successfully used a "skiodan" acacia mixture as a contrast medium for uterosalpingography, and suggested that this mixture could be used for bronchography also. Morales[40] tested visco-rayopake, a substance containing polyvinyl alcohol and used by Rubin[51] for hysterosalpingography, for bronchography, but found it too irritant to the bronchial mucosa.

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† "Xumbradil Viscous B" was kindly supplied by Astra Pharmaceutical Products, Inc., Worcester, Massachusetts.
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The next important progress in the search for a suitable bronchographic medium was realized when the value of carboxymethylcellulose as a viscosifying agent was recognized by Swedish workers. This water-soluble organic substance was the subject of a thorough research by American workers during the war in an effort to find a substitute for blood plasma in experimental shock in animals.[29] Morales and Heiwinkel,[40] taking advantage of this property of carboxymethylcellulose, were able to combine it with umbradil (iodopyracet, U.S.P.) and thus prepare a relatively viscous contrast material (xumbradil-viscous B) with which they could obtain satisfactory visualization of the tracheobronchial tree. Since the appearance of their paper, other workers have confirmed the practicality of this medium and its relative harmlessness and superiority to lipiodol. Taking the lead given by the Swedish workers, Fischer[15] prepared a somewhat more viscous contrast material by increasing the percentage of carboxymethylcellulose in his compound. Since then, other similar preparations have been made in France, Germany and England, which we shall discuss later. The latest addition to these new media is "dionosil" which promises to have certain advantages over the media used hitherto by the Swedish and German workers. It is evident that further progress in this field will be made as more interest in the perfection of an ideal contrast medium for bronchography develops.

THE CONSTITUENTS OF THE NEW BRONCHOGRAPHIC CONTRAST MEDIA

All available new contrast media for bronchography contain two main ingredients, one of which is a water-soluble radiopaque material, the other a substance which is added to increase the viscosity of the former, and thus make it less readily absorbed in the respiratory tract. The contrasting substance used in all of the currently offered media is a water-soluble organic iodide (3,5-diiodo-4-pyridone-N-acetic acid diethanolamine) or a very close derivative of it such as the one used in dionosil (n-propyl 3:5-diiodo-4-pyridone-N-acetate). The former substance is a brand of iodopyracet, U.S.P., which has been marketed in this country for a long time as diodrast. The viscosifying ingredient in the compound is a water-soluble cellulose ether, sodium carboxymethylcellulose or the sodium salt of the glycolic ether of cellulose. The type of cellulose ether and its concentration in the mixture determine the viscosity of each medium. Furthermore, all cellulose ethers used as viscosifying agents are not alike, and their quality depends on their molecular weight, which, in turn, is determined by the source of the raw material and the method by which they are made. Thus, the apparent disparity between the viscosities of xumbradil viscous B and ioduron B, in spite of their identical concentration of carboxymethylcellulose, is due to the fact that the latter medium contains carboxymethylcellulose of low molecular weight. It should be emphasized here that methylcellulose used by Peck, *et al.*[45] should not be confused with carboxymethylcellulose which has been employed by others. This differentiation is important in that the biologic study carried out with one medium cannot be generalized and applied to others. Methylcellulose is nonreactive while sodium carboxymethylcellulose has a reactive carboxyl group.[41]

Information with regard to the exact chemical constituents of these media has been scanty and fragmentary. Most authors have failed to give a description of the physical and chemical properties of the particular medium which they used. For this reason, we have been unable to gather sufficient data with regard to the properties of water-soluble contrast media to enable us to present a comprehensive review of the subject. However, we have attempted to summarize the available information on such media in Table 1.

There is a wide range of viscosity among the currently marketed bronchographic media in Europe. The more viscous have

TABLE I

COMPOSITIONS OF VARIOUS BRONCHOGRAPHIC MEDIA

Name of Product and Manufacturer	Contrast Substance and Percentage Used	Viscosifying Agent and Amount Used in 100 cc. of Medium	Viscosity in Centripoise	Other Agents Added	Investigators
Xumbradil Viscous B, Astra Pharmaceutical Products, Inc., Worcester, Massachusetts	Umbradil (Brand of Iodopyracet, U.S.P.) 50 gm. %	Carboxymethylcellulose 2.5 gm. %	900 cps. at 37° C.	Xylocaine 0.5 gm. Sterile water 100 ml.	Morales and Heiwinkel[40]
Ioduron B, Joduron B, Cilag, Schaffhausen, Switzerland	Ioduron (Brand of Iodopyracet, U.S.P.) 50 gm. %	Carboxymethylcellulose (different from the one used above) 2.5 gm. %	25,000–30,000 cps. at 20° C.	Nicotinic acid amide-N-acetyl bromide? Methyl parahydroxybenzoate 0.1 gm. Distilled water 100 ml.	Fischer[15,16,17]
Perabrodil M 60% Viscous & Perabrodil M1, M2, M3 50%, Viscos. Bayer, Germany	Parabrodil 50 to 60%	Carboxymethylcellulose added to . . .	3,500–4,000 cps. at 37° C. 6,000 at 36°	Penicillin and streptomycin added by investigator	Vieten[62,63]
Diodone Visqueuse, Guerbet, France	Diodone	Carboxymethylcellulose added about 2% to make the desired viscosity	4,000 cps. at 37° C.	No information could be obtained	Délie and Sourdat[10]
Methocel-Diodrast, Winthrop-Stearns, U.S.A.	Diodrast, 50 gm. %	Methylcellulose 1.75 gm. %	4,000 cps. at 37° C.	None	Salzman, Peck and Neerken[52,45,46]
Dionosil, Glaxo Laboratories, Middlesex, England	Propyldione 50 gm. of crystals suspended in 100 cc. of water	Sodium carboxymethylcellulose less than 1 gm. %	Viscosity has not yet been determined due to technical difficulties involved	Sodium citrate as buffer, sodium chloride to make it isotonic; also, a wetting agent, benzyl alcohol (antiseptic)	Don[12] Adler, *et al.*[1] Others[26,37,60]

the advantages of being absorbed less readily than the dilute ones in the bronchioles, thus they permit an unhurried fluoroscopic and roentgenographic examination of the tracheobronchial tree. However, this advantage seems to be offset by the untoward reactions which it is alleged[24] are produced in the lung parenchyma.

In addition to these two main ingredients, the manufacturers add other substances such as local anesthetics (xylocain in umbradil viscous B; wetting agent such as nicotinic acid amide-N-acetyl bromide in ioduron B and dionosil; antihistaminics in diodone visqueuse; disinfectants in ioduron B; and, finally, antibiotics in perabrodil M). Some of these substances are often added or omitted according to the desires of the investigators using them. Distilled sterile water is added to make up the desired concentration in all of the available media.

BIOLOGIC EFFECTS OF WATER-SOLUBLE MEDIA FOR BRONCHOGRAPHY

In bronchography, the contrast portion of water-soluble media is removed from the lungs within one to four hours depending on the viscosity of the medium used. Exception is made for "dionosil," a medium in which the contrast crystals are suspended in water or oil and are removed within one to three days from the pulmonary bed. The iodine compounds are absorbed from the pulmonary tissues by means of lymphatic venous channels and excreted via the kidneys. This is evidenced by good visualization of the pelves and calyces of the kidneys which is often obtained in a roentgenogram of the abdomen taken shortly after bronchography (Fig. 1). The relative safety of these contrast media has been established by their long standing use in intravenous and retrograde pyelography and in angiography. The mechanism of excretion and the mode of action of these contrast substances on the vital organs of the human body have recently been reviewed by Josephson[31] and Sandström;[53] a repetition of their findings here appears unnecessary. However, it is important to note that although such substances are irritating to pulmonary epithelium, they have never been incriminated in the production of chronic pathologic changes in the lungs. Hellström and Holmgren[25] reported non-specific inflammatory changes in the lungs of rats and rabbits, following in-

Fig. 1. Roentgenogram of the kidneys made thirty minutes after the introduction of aqueous iodine solution for contrast in the bronchial tree. Clear shadows of the kidney pelves are already apparent indicating rapid absorption.

trabronchial injection of umbradil, which began to subside after twenty-four hours. Similar changes were noted when xumbradil viscous B or isotonic saline were used instead of umbradil. In all of these experiments, no trace of any lung pathology could be found after three weeks. The transient irritating effect of these substances is evidenced by severe spasm of the smooth muscles of the bronchial tree (Fig. 2) and subsequent violent coughing after intrabronchial injection in man. Brandenstein, *et al.*[26] investigated the effect of bronchial instillation of ioduron B in guinea pigs. They observed no permanent damage to the tissues of the vital organs (including the lungs) of the animals up to three months following the above procedure. It should be mentioned that they did not use a special differential stain for the demonstration of carboxymethylcellulose in the tissues.

The Fate of Carboxymethylcellulose. Although carboxymethylcellulose is a water-soluble substance, it is not absorbed by bronchial epithelium or the pulmonary vascular system. Its elimination from the broncho-alveolar lumen is accomplished by means of peristalsis, ciliary action, cough and phagocytosis. The rate of disappearance of carboxymethylcellulose from the lungs, and the delayed pulmonary reaction caused by its presence has not yet been completely determined. Being a non-opaque substance, its removal from the pulmonary bed cannot be followed by means of roentgenograms as is the case with iodopyracet. The only means of its recognition is by histologic examination using special differential staining technique.

Hellström and Holmgren[25] could find no trace of carboxymethylcellulose in the lungs of rats and rabbits two weeks after these animals were subjected to intrabronchial injection of umbradil viscous B or carboxymethylcellulose. In contrast to these findings, Vischer,[64] in a similar experiment in rats and guinea pigs, was able to demonstrate traces of carboxymethylcellulose in the lungs of these animals up to four months following their injection with ioduron B. He states that carboxymethylcellulose acts as a foreign body causing formation of giant cells, leukocytosis and fibrosis. He concludes that a portion of the lung may thus become useless. He also found these changes in the resected lung specimens of patients who had had bronchography with ioduron B some time before their operation. These observations are in contradiction to those made by Zollinger[70] who only noted non-specific reaction of a very temporary nature in the lungs of guinea pigs in which percutaneous injection of ioduron B had been made. He also was unable to demonstrate any changes in the resected lung specimens of man which could be attributed to the use of ioduron B. Zollinger concludes that Vischer's findings were probably due to the use of thionine tartaric acid stain which does not differentiate carboxymethylcellulose from mucous secretions which are often found in chronically diseased lung. However, this

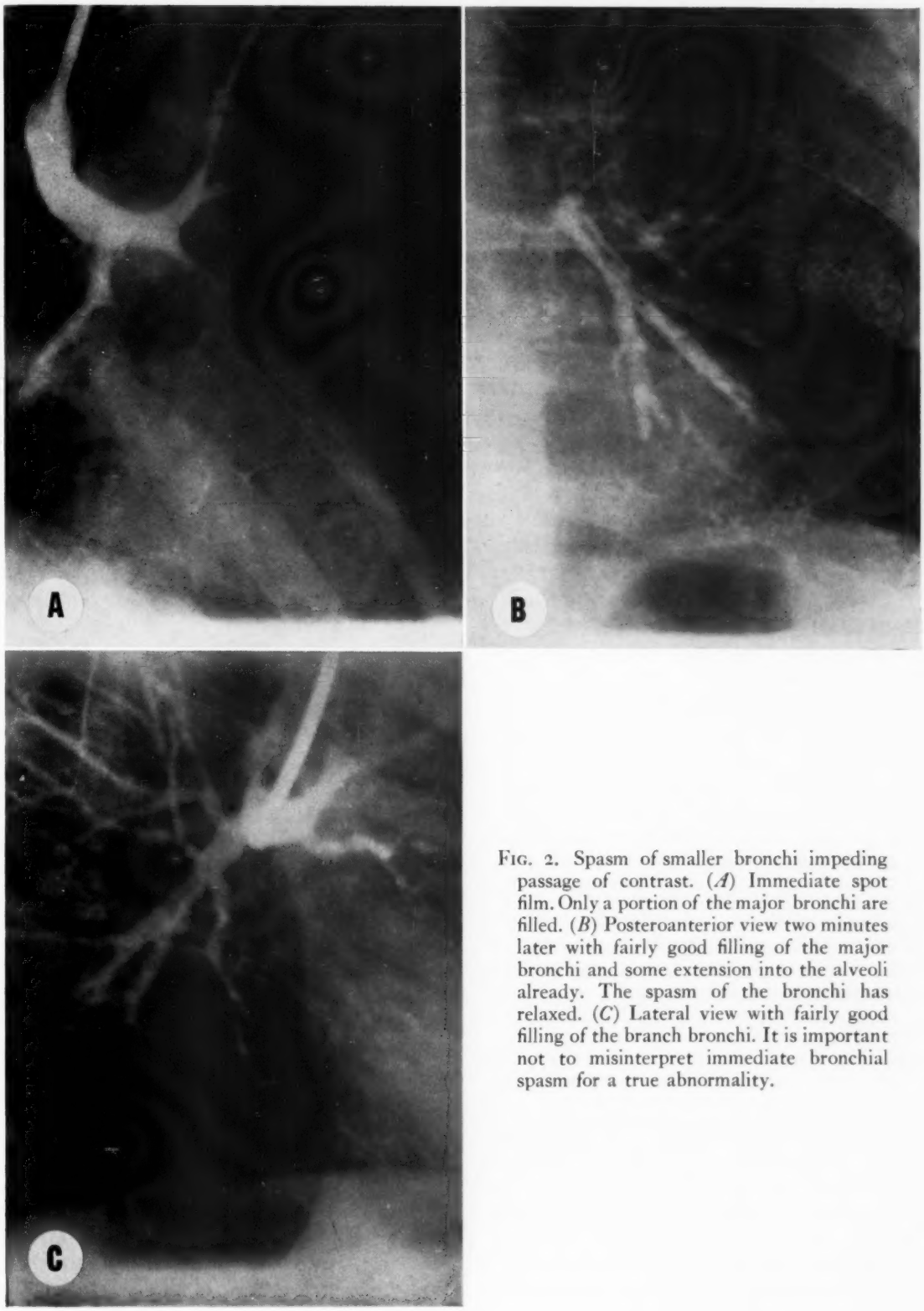

FIG. 2. Spasm of smaller bronchi impeding passage of contrast. (*A*) Immediate spot film. Only a portion of the major bronchi are filled. (*B*) Posteroanterior view two minutes later with fairly good filling of the major bronchi and some extension into the alveoli already. The spasm of the bronchi has relaxed. (*C*) Lateral view with fairly good filling of the branch bronchi. It is important not to misinterpret immediate bronchial spasm for a true abnormality.

was denied promptly by Vischer [64] who, in a footnote to Zollinger's article, declared that he could not find the so-called mucous granuloma in the resected lungs of patients who had not had bronchography with ioduron B prior to their operation. Werthemann and Vischer[68] repeated the experiments in rats, using a special improved differential stain, and confirmed the previous findings. The changes seen in the lungs of the rats were totally different from the usual mucous granulomata. Although these changes were slight in the experimental animals, they believe that in human lungs such changes are far more extensive and constitute a serious objection to the use of ioduron B for bronchography in man. The only experiment in the United States with regard to this aspect of water-soluble media has been done by Peck, *et al.*[45] but they used methocel-diodrast, not carboxymethylcellulose.

It has been postulated that the discrepancies in the findings of various investigators could lie in the inherent difference of the contrast media which they used. To settle this problem, Hellström[24] undertook a series of experiments in rats. Intrabronchial injection of xumbradil viscous B was made in one group, while ioduron B (the medium used by Vischer) was administered similarly in another group of rats. The findings in the lungs of rats which were instilled with xumbradil viscous B were essentially the same as reported in his previous paper, consisting of "absolutely" minimal changes after a long time but "no foreign body reaction." By contrast, he found irreversible changes consisting of induration and a chronic inflammatory process in the lungs of rats which were subjected to intrabronchial instillation with ioduron B. He suggests that this difference in reaction of the two media is probably due to the high viscosity of ioduron B and recommends a similar study in man using both media.

Systemic Reaction of Carboxymethylcellulose. Carboxymethylcellulose is a harmless cellulose derivative with a wide range of usefulness. During recent years, it has been used for various purposes from thickener for ice cream to an antacid in the treatment of peptic ulcer. Schelanski and Clark[55] used it as a vehicle for medication. The only unfavorable report on the systemic effect of carboxymethylcellulose was made by Brandenstein, *et al.*[8] Using ioduron B (containing 2.5 grams per cent of carboxymethylcellulose) for bronchography in 10 patients, they found transitory hepatic and renal changes in a high proportion of cases. All these changes were of a temporary nature and disappeared completely on later examination. Earlier, Brandenstein[5] had reported "No harmful effects have been found to date" in 25 patients following bronchography with ioduron B. Werle[67] found no evidence of absorption or any deleterious effect in man or animals after oral ingestion of carboxymethylcellulose. Its storage in the reticuloendothelial system after intravenous administration in dogs has been demonstrated by Hueper.[29] Hellström and Holmgren[25] showed that the portion of carboxymethylcellulose which is not expectorated is phagocytized by pulmonary phagocytes and removed completely from the lungs in two weeks. Zollinger[70] found the phagocytized carboxymethylcellulose in alveolar septa, peritoneum, and the lymph channels of the intestine after simultaneous intrapulmonary and intraperitoneal injection of ioduron B.

Technical Factors Peculiar to Water-Soluble Bronchography. Anesthesia. Almost all water-soluble bronchographic media currently in vogue have the common property of being irritant to pulmonary epithelium. Thus, their introduction into a bronchus causes severe spasm of the smooth muscles and violent cough if satisfactory anesthesia of the respiratory tract is not obtained prior to bronchography. It is commonly agreed that more thorough anesthetization of the tracheobronchial tree is required for bronchography with these media than with lipiodol. On the other hand, it is known that fatali-

ties due to this roentgenographic procedure have been invariably attributed to individual hypersensitivity to local anesthetics which is a risk most otolaryngologists are reluctant to take. To overcome this difficulty, some investigators have attempted to find a local anesthetic agent which would be more effective and, at the same time, less toxic than cocaine or pontocaine. Recently, Vieten and Keil[32] tested the efficacy of several local anesthetics (pontocaine, oxycaine, salicaine, bronchocaine and xylocaine) for water-soluble bronchography and found that salicaine, 1 per cent, was the anesthetic of choice for this procedure. Worth and Heinz[69] studied the effectiveness of a new local anesthetic (rhenocaine), P-n butylaminosalicylic acid-diethylaminoethylesterchloralhydrate, and found it to be superior to cocaine and pontocaine.

The work of Frommhold[20] is of interest in that he used intravenous curare following insertion of the tracheal tube. This causes complete paralysis of the larynx and muscles of respiration necessitating artificial respiration for the resuscitation of the patient following bronchography. Breathing is stopped completely for a few seconds during which roentgenograms are obtained. This is claimed to be less dangerous than the use of local anesthesia by the conventional method. Recently, Gidlund[22] has described a very ingenious device for surface anesthesia by locally spraying the course of the respiratory tract by means of a tube with interchangeable nozzles. The search for a safe local anesthetic agent, and a better method of anesthetization of the respiratory tract is far from being complete. In the meantime, familiarity and development of proficiency in any one technique appears to be the best safeguard against fatalities in bronchography.

Technique of Intubation and Bronchography. In general, the method of endotracheal catheterization has been rightly used in this country for bronchography. The simplicity of technique and the uniformly good results obtained by this method make it the procedure of choice. The various methods of introduction and their advantages have already been extensively reviewed by Vickers[61] and many others.[7,62] With regard to roentgenography, the Europeans seem to prefer the use of spot films and small roentgenograms while in this country large films are desired. This is partly due to economic reasons and partly due to special roentgenographic facilities which are available in Europe and especially in the Scandinavian countries. By means of such devices good small roentgenograms of patients, positioned under direct fluoroscopic vision, are produced. Such films compare favorably to our large films.

A SURVEY OF CLINICAL EXPERIENCE WITH VARIOUS MEDIA

Xumbradil viscous B originally used by Morales and Heiwinkel[39] is the only one of the water-soluble media which has had a fair clinical evaluation in this country. Other media subsequently produced by European pharmaceutical houses and used by German, Swiss, French and Italian investigators were either unavailable for research or gave disappointing results when tried in the United States. It should be emphasized again that no two water-soluble media for bronchography currently available for clinical trials have identical effect upon the pulmonary epithelium. Each medium should be investigated separately with regard to this vital tissue. Up to the present time, no deleterious effect upon the lungs has been reported from the use of xumbradil viscous B for bronchography. The results of clinical trials with ioduron B and methocel-diodrast have already been mentioned. To our knowledge, diodone visqueuse and perabrodil M have not yet been introduced in this country. Dionosil, produced by Glaxo Laboratories Limited (England) has had limited clinical tests in Britain and elsewhere and is currently being distributed here for investigative purposes only. At the present time, several research centers

TABLE II

SUMMARY OF CLINICAL TRIALS ON BRONCHOGRAPHY WITH WATER-SOLUBLE MEDIA

Investigators	Medium Used	Favorable Clinical Impression Obtained By All Except Those Given Remarks Below
Morales and Heiwinkel[39,40]	Xumbradil Viscous B	———
Flipse, *et al.*[19]		———
Fawcett[13]		———
Atwell and Pedersen[2]		———
Welin[68]		———
Pope and Ødegaard[47]		———
Magnenat[36]	Ioduron B	Foreign body granulomata found in lung of 3 autopsied cases
Bouvet[4]		———
Baranger, *et al*[3]		———
Brown[6]		Contrast medium is irritating, hence requiring more anesthesia
Brandenstein[5]		———
Fischer[15,16,17]		———
Gambaccini[21]		———
Rogers and Weens[50]		———
Scarinci[54]		———
Vischer[64]		Granulomatous changes found in the lung specimens of patients who had previous bronchographic examinations with Ioduron B
Vieten, H.[62,63]	Perabrodil M	———
Willman[46]	Perabrodil M 60%	———
Délie and Sourdat[10]	Diodone Visqueuse	———
Metras, *et al.*[7,38]		Recommended contrast medium for segmental bronchography and in patients with cardiopulmonary difficulties
Peck, *et al.*[45,46]	Methocel-Diodrast	Although satisfactory bronchograms obtained, contrast medium was discarded due to difficulties encountered in maintaining its stability
Salzman, *et al.*[52]		
Adler and Fainsinger[1]	Dionosil	———
Don[12]		———
Mackay and Bodeur[35]		———
Rendle-Short[49]		———
McKechnie[37]		———
Tomich, *et al.*[60]		———
Our own preliminary study		———

in this country are engaged in evaluating this product. Our own clinical experience with dionosil will be published at the conclusion of our studies in a separate paper. For the sake of brevity, the clinical experience of various investigators with water-soluble media is summarized in Table II.

The rapid absorption of the new media, and the opportunity thus afforded for convenient observation of the rate of disappearance of the media from the pulmonary tissues led Lenzi[33,34] and several other Italian investigators[9,21,42] to introduce the concept of functional bronchography. According to Lenzi, with lipiodol only two stages of bronchography (bronchial and alveolar stages) were recognized; however, with water-soluble media there

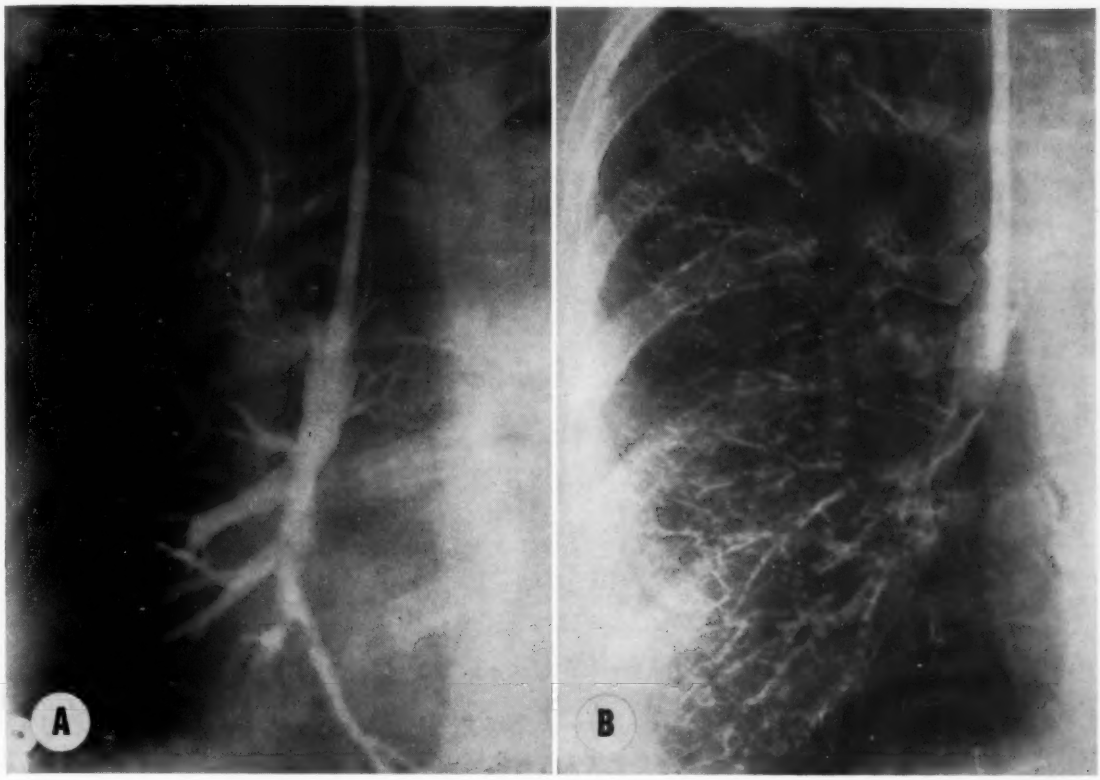

FIG. 3. Normal bronchogram with aqueous contrast illustrating spot film technique. (*A*) First spot film taken immediately after introduction of contrast, major bronchi being well outlined. (*B*) Three minutes later spot film shows extension into smaller bronchi and to some degree into the alveoli. Fairly good mucosal relief pattern of the bronchial tree is obtained in this fashion.

is a third stage during which the contrast medium is absorbed by the lymphatic and venous channels of the lungs. The duration of this lymphovenous stage has been found to correlate well with the physiopathologic state of the pulmonary tissues. This idea is somewhat similar to the concept developed by Di Rienzo[11] about bronchial dynamism in determining the reversibility of a given bronchiectasis. Other pulmonary researches[27,65] have been carried out by means of water-soluble media whose description is beyond the scope of this paper.

CLINICAL EXPERIENCES WITH XUMBRADIL VISCOUS B

Since November, 1951, we have been using xumbradil viscous B as the contrast medium for bronchographic examinations at the Ancker Hospital, St. Paul, Minnesota. During a two-year period, we did 74 such studies in 64 patients. These examinations were carried out either for the purpose of accurate anatomic localization of bronchial segments prior to surgery in cases of tuberculosis or bronchiectasis or as a diagnostic procedure in patients in whom the nature and extent of the suspected pulmonary pathology could not be adequately explained by other, more routine investigative methods.

Technique. Following thorough anesthetization of the upper respiratory tract by an otolaryngologist, the patient is immediately brought to the radiologic department where the contrast medium is introduced, through a catheter already placed into the desired bronchial segment under direct fluoroscopic vision. Without delay,

Table III

DIAGNOSTIC QUALITY OF BRONCHOGRAMS

Quality of the Roentgenograms		Number of Patients
Excellent	All Diagnostic	31
Good		19
Fair		12
Failures due to inadequate anesthesia and poor contrast (non-diagnostic)		5
Films were not available for this review. However, other records indicated that diagnostic films were obtained		7
Total		74
Percentage of Diagnostic Bronchograms		93%

the necessary spot films are obtained by the radiologist immediately upon filling the bronchial branches (Fig. 3). This is essentially the technique used by European workers as described in detail by Délie and Sourdat.[10] Alveolar filling and subsequent clouding of the lung fields frequently occur when the routine method of bronchography with lipiodol is followed. Furthermore, by the routine method, especially with blind filling, one cannot be assured of the demonstration of the desired bronchus.

Analysis of Our Cases and Results. Seven of our patients were older than sixty years of age, 8 were below the age of ten, and the remainder were distributed almost evenly between the ages of ten and sixty. This breakdown with regard to age is significant in that bronchographic examinations in the extreme age groups have been much less satisfactory than in the adult and the middle aged groups. This is partly due to the poor tolerance of patients in extreme age groups to the local or general anesthesia which is required in this examination. We have obtained diagnostic bronchograms in most instances except where coughing due to inadequate anesthesia prevented satisfactory filling of the bronchial tree. Reviewing our material we have attempted to classify our bronchograms according to their diagnostic quality. The result appears in Table III.

Our failures were in cases in which satisfactory anesthesia could not be obtained in spite of the use of maximum permissible dose of cocaine, or in the debilitated patients who had generalized weakness and poor ventilatory exchange. In 2 of these patients, we have been able to obtain satisfactory bronchograms on subsequent examinations. In occasional instances, we have not hesitated to use more anesthesia when the maximum dose was not effective. However, in these cases, we came to learn that the increase in the dose of cocaine did not materially improve the state of local anesthesia probably due to their individual refractoriness to this drug.

We have been able to demonstrate a variety of pulmonary diseases with this method of bronchography. Oudet[44] states that the exploration of pulmonary cavities is a major indication for the use of water-soluble media. This is contrary to the view held by Metras, *et al*[38] who maintain that pulmonary cavities cannot be filled with water-soluble media and that such media should be only for patients with cardiac and pulmonary insufficiency or with severe emphysema. We feel that this differentiation is rather arbitrary and unjustified. Our experience with xumbradil viscous B leads us to believe that this medium can be used in all instances where bronchographic examination is indicated. We have successfully used xumbradil viscous B in all patients in whom a demonstration of the bronchial tree was deemed necessary, including a great variety of indications, regardless of the lesions suspected, as long as there was no medical contraindication to a bronchographic examination. Table IV briefly outlines the number of diagnoses which have been subsequently proved by bronchoscopy or pathologic examinations after surgery.

Representative bronchograms of some of the lesions in Table IV are illustrated in Figures 4, 5, 6 and 7.

TABLE IV

VARIETY OF PULMONARY LESIONS DEMONSTRATED BY XUMBRADIL VISCOUS B

Type of Lesion Demonstrated	Number of Cases	Type of Lesion Demonstrated	Number of Cases
Diagnostic mapping	25	Unresolved pneumonia	1
		Right middle lobe syndrome	1
Tuberculous bronchiectasis and cavitations	14	Bronchial obstruction (one due to a foreign body)	2
Bronchopleural fistula	2	Segmental atelectasis	2
Non-tuberculous bronchiectasis	14	Filling defect in the bronchus due to previous surgery	2
Tumor	1		

FIG. 4. Anomalous right upper lobe bronchi. The anatomic variation whereby the posterior branch of the upper lobe bronchus arises from the same branch as the anterior axillary branch is shown. Note bronchiectasis in the apical segment which is well demonstrated.

Complications. We have found no particular untoward side effect that could be directly attributed to the use of xumbradil viscous B. The complications have been those which are inherent in the procedure itself regardless of the type of the medium used. The most frequent complication has been a slight degree of pyrexia, from 0.2 to 3 degrees F., which occurred in about 59

FIG. 5. Atelectasis of the anterior segment of the right upper lobe. Note crowding of the bronchi in this area (arrows).

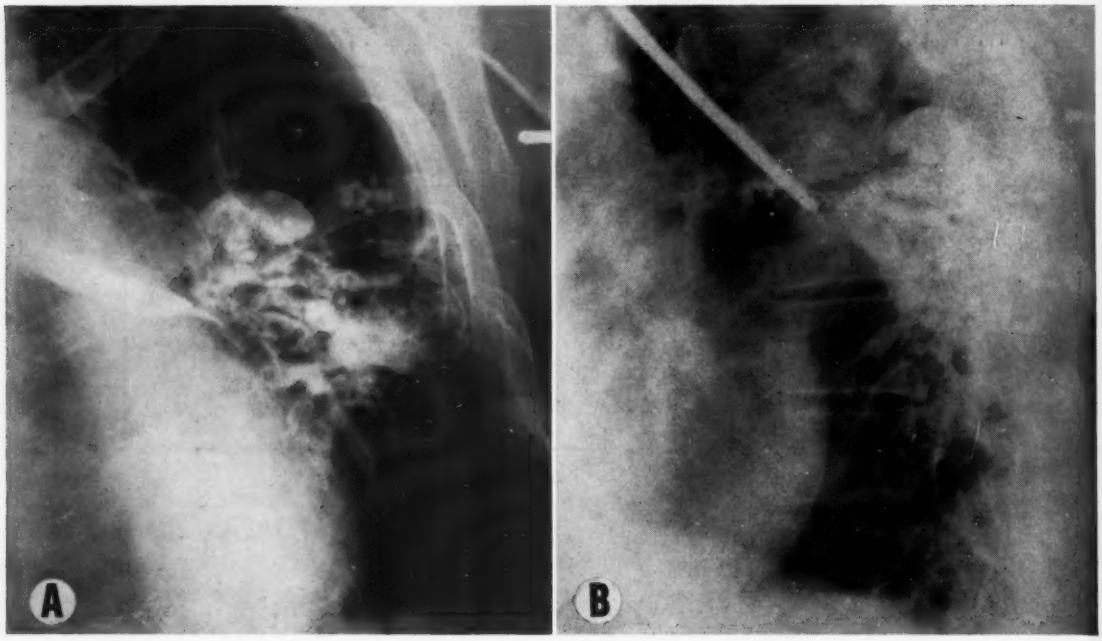

Fig. 6. Cystic type of bronchiectasis in the apical segment of the left lower lobe well demonstrated. At operation this proved to be a tuberculous bronchiectasis.

Fig. 7. Bronchopleural fistula. Collection of contrast can be seen under the ribs in the left apical pleural pocket (arrow). The fistula was later demonstrated at operation.

per cent of our cases. In the great majority of these cases, the temperature rise seldom exceeded 100° F. Only in 6 cases was the pyrexia over this limit. A review of the history of these 6 patients revealed the following pertinent findings: Three had moderately advanced pulmonary tuberculosis with cavitations, 1 had a bronchopulmonary fistula, 1 had obstruction to the lingular segment of the left upper lobe, and the last had no evidence of any pulmonary disease.

When the charts of our patients were being reviewed in search of the above data, we found that several patients had one or two bronchoscopic examinations some time before or after their bronchographic procedure. A check of the temperature record revealed some degree of pyrexia during the former procedure also. A rough statistical analysis disclosed the interesting fact that the percentage of cases that developed pyrexia following bronchoscopic examination was essentially the same as that of those who developed pyrexia following bronchography with xumbradil viscous B.

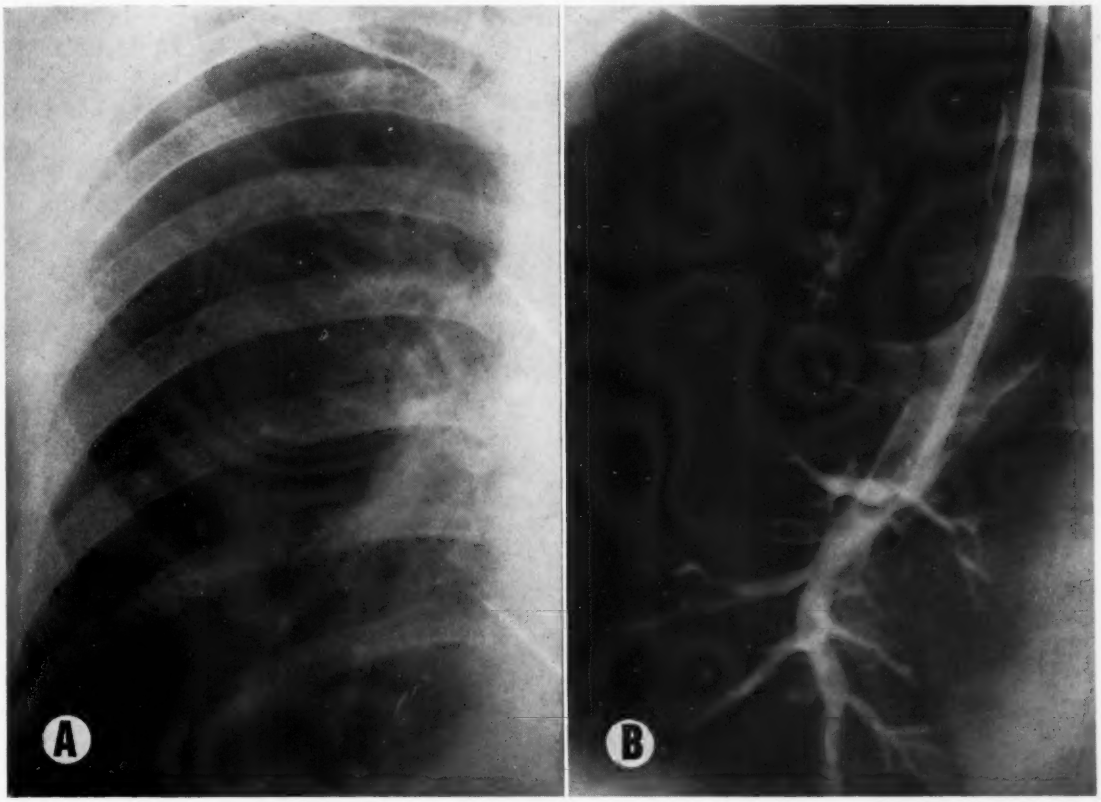

Fig. 8. Rapidity of disappearance of contrast medium. (*A*) Roentgenogram of the right lung forty-five minutes following bronchography showing total disappearance of the contrast. (*B*) The appearance of the bronchi in the same case immediately following introduction of xumbradil viscous B.

In addition, it was noted that the rise of temperature was more likely to occur in cases that had extensive tuberculous or non-tuberculous bronchiectasis with cavitations. The frequency of this complication has been reported by various workers to be from 39 to 53 per cent.[19] Our findings are essentially in keeping with the views of those who maintain that pyrexia following bronchography is due to endobronchial manipulation rather than due to local or systemic reaction of the body to contrast medium.

With regard to the possible harmful effect of xumbradil viscous B upon the pulmonary tissue, we cannot offer any evidence to refute or substantiate the findings of Vischer[64] who noted the occurrence of a non-specific granulomatous reaction with foreign body giant cell formation in the resected lungs of patients who had had bronchography with ioduron B prior to surgery. Unfortunately, we did not have facilities to make a differential stain of our microscopic preparations for the demonstration of sodium carboxymethylcellulose in the surgical specimens of patients who had bronchography with xumbradil viscous B prior to operation. However, the pathologic reports and subsequent review of the microscopic sections in these patients failed to reveal any unusual finding that could not be directly attributed to the lesions for which surgical removal was undertaken.

The contrasting susbtance of the xumbradil viscous B disappears readily from the pulmonary bed, and usually no traces of it can be demonstrated roentgenographically about an hour following bronchography (Fig. 8). Check-up films taken periodically and followed for a period

ranging from two months to two years in most of our patients did not disclose any evidence of pulmonary pathology in which xumbradil viscous B could be incriminated.

We have had no case of death attributable to this roentgenographic procedure in our series. Severe anaphylactic reaction, and death following bronchography, although rare, can occur in the best of hands, and have been reported repeatedly in literature. Invariably these violent reactions have been attributed to anesthetics. Jackson (quoted[69]) reported 12 such accidents due to hypersensitivity to pontocain. One patient in our series developed severe dyspnea and cyanosis which necessitated artificial respiration and administration of oxygen. The respiratory difficulty in this case was attributed to inadvertent filling of the entire tracheobronchial tree by the contrast medium. This was shown by roentgenologic examination. It was postulated that the temporary coating of the major portion of the pulmonary epithelium by carboxymethylcellulose had interfered with adequate ventilatory exchange.

Uses of Xumbradil Viscous B in Patients with Pulmonary Tuberculosis. The use of bronchography in tuberculous patients has been a matter of debate ever since this diagnostic procedure came into popularity. Prior to the introduction of segmental resection in the treatment of pulmonary tuberculosis, this debate was more or less academic. Bronchography was seldom necessary or indicated in patients with pulmonary tuberculosis. However, the current wide acceptance of surgical resection of diseased segments of the lungs and the necessity for accurate localization of diseased areas, have made bronchography an important tool in the correct treatment of this disease. The reluctance of radiologists to perform bronchography in the tuberculous patient has been due to the fear of spreading the disease to healthy tissues by means of aspiration of the infected contrast medium. However, the advent of chemotherapy, and the rare occurrence of such accidents in large published series[28,30,48,57] militate against adherence to the above rigid precaution. We have performed a total of 36 bronchographic examinations in 32 patients with proved pulmonary tuberculosis. Excepting one instance, the history of which is reported below, we have been unable to demonstrate any increase in the extent of their disease or any clinical evidence of reactivation during a period of follow-up study ranging from one to twenty-seven months following bronchography.

REPORT OF CASE

C.H., a twenty-six year old married nurse was admitted to the hospital in November, 1951, with a small area of infiltration with cavitation in the right perihilar region. Following a course of chemotherapy, the apical segment of the right lower lobe was resected in February, 1952. In September, 1952, she chose to leave the hospital while having a cough and a low grade fever. She returned to the hospital in October, 1952. At this time, she had a positive sputum, and bronchography revealed a fistulous communication between the site of the previously resected segmental bronchus and the right pleural cavity (Fig. 9). At this time, there was no evidence of parenchymal infiltration in either lung field. However, a repeat roentgenogram of the chest two weeks later showed a soft infiltration in the right subclavicular area which was attributed to re-infection by means of the aspirated infected medium from the infected stump of the apical bronchus of the right lower lobe. In retrospect, this patient had a positive sputum prior to bronchography, and was coughing a great deal, and the possibility that she could have infected other parts of the lung spontaneously cannot be excluded.

It should be added that all of our tuberculous patients in this series were receiving vigorous chemotherapy prior to bronchography, and were continued on the same regime for some time following this procedure. Sporadic cases of spread of pulmonary tuberculosis developing after bronchography with water-soluble media have been reported by others. Flipse, *et al*[19] have collected 7 reported and unreported cases in which this complication developed. How-

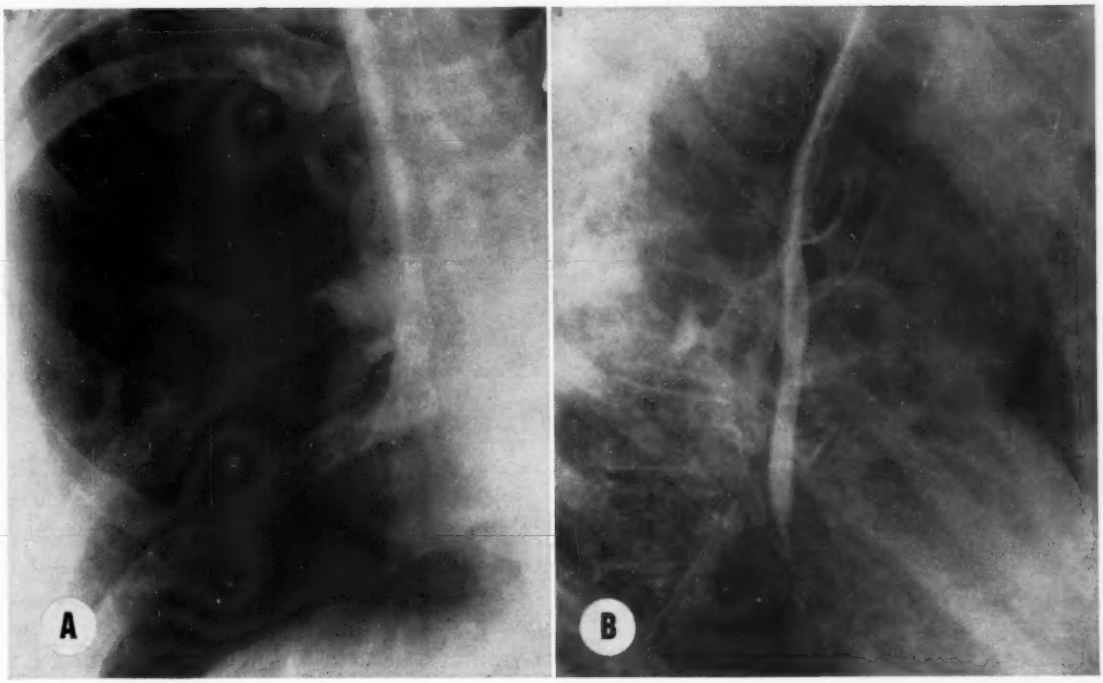

Fig. 9. (Case CH) Bronchial fistula communicating with cavity in lung. The contrast may be seen collected in a cavity and a direct communication posteriorly with the bronchus is clearly delineated. Some contrast has been swallowed and is seen in the esophagus.

ever, they doubt if the spread in their cases was unequivocally assigned to this procedure. At the present time, various workers in the United States and abroad perform iodized oil and water-soluble bronchography in patients with pulmonary tuberculosis, with impunity. Gordon, *et al*[23] strongly recommend bronchography in tuberculous patients for better guidance of surgical treatment in all cases. Ibers, *et al.*[30] condemn the use of iodized oil in tuberculous patients, but they do not hesitate to use the water-soluble medium perabrodil M. They report no evidence of spread in 43 examinations on such patients. Antibiotics were given parenterally several days before and after the procedure. Nevertheless, they caution against injudicious use of bronchography in tuberculous patients, and they advise that it should be resorted to only when all other means of examinations have been exhausted and only for localization of lesions prior to surgery. It appears that when the performance of this procedure is indicated, the choice of the contrast medium is immaterial, although more reluctance in the use of lipiodol in tuberculous patients has been shown in the past by European workers.[19]

THE SELECTION OF MEDIUM AND DISCUSSION

Although we have been able to obtain persistently good roentgenograms of the tracheobronchial tree by means of xumbradil viscous B, we do not believe, by any means, that this medium is the ideal substance for bronchography for it has the following serious drawbacks: (1) Rapid disappearance from the bronchial tree and subsequent alveolarization; (2) Immediate irritating effect upon the pulmonary epithelium and the necessity for deep surface anesthesia; (3) The rapidity of its disappearance does not permit the use of the routine method of roentgenography which is desired by many radiologists; (4) Its irritant effect upon the pulmonary tissue sometimes produces severe spasm of the smooth muscles of the bronchioles. This

phenomenon often results in incomplete filling of the bronchioles which may mislead the radiologist in his interpretation.

In spite of the above shortcomings, we feel that xumbradil viscous B is a satisfactory medium for the demonstration of endobronchial diseases. Its easy elimination, its rapid mixture with bronchial secretion, its adequately visible roentgenographic density, together with the absence of any delayed pulmonary reaction make it nearly an ideal bronchographic medium.

From the available evidence as detailed in this paper, xumbradil viscous B appears to be non-toxic, readily absorbed, and by virtue of its low viscosity, should be the least likely of the various media to produce chronic granulamotous changes in the lungs. It has been argued that its rapid absorption does not permit the examiner to obtain a good fluoroscopic view of the bronchial tree and persistent subsequent roentgenograms. There are very few parallel studies in the literature where the percentage of satisfactory bronchograms with these media are compared with those obtained by lipiodol or other oily media. Neerken, *et al.*,[46] using lipiodol, obtained satisfactory bronchograms in 84 per cent of the examinations done at an Army hospital. Their result was compared favorably with that obtained by Peck, *et al.*[46] who were only able to produce diagnostic bronchograms by means of methocel-diodrast in 66 per cent of the examinations in a civilian general hospital. There are several serious objections to this comparison. The percentage of satisfactory bronchograms obtained in an Army hospital where the patients are relatively of a younger age group cannot be compared to those produced in a civilian hospital where the average age of the patients is higher. Furthermore, the technique used in the performance of bronchography with water-soluble methocel-diodrast was not of such a nature as to minimize disadvantage of its rapid absorption. With the technique described in this paper, we have been able to obtain 93 per cent diagnostic bronchograms. This percentage covers a period in which we were not deft in our procedure; with further experience we may be able to improve this percentage. Furthermore, the material reported includes bronchography performed by a number of different residents; their initial inexperience in technique has probably been a factor in our results.

Up to the time of this writing, we have not been able to find a thorough follow-up study of patients who have had bronchography with diodone visqueuse. The objection of Vischer[64] to the use of ioduron B and its high viscosity makes us hesitant to recommend it at this time. Perabrodil M viscous groups of media had extensive trials by Vieten and Willman,[46] but again their high viscosity and their possible deleterious effect upon the lungs should be clarified before they can be used indiscriminately. Clinical trials with dionosil have not been sufficient to warrant its use in routine noninvestigative bronchography. For the above reasons, we feel that xumbradil viscous B with the method which has been described can be used without hesitation until clinical trials on dionosil are completed. In the meantime, it is hoped that better non-irritating and nontoxic contrast media, which would not require high anesthetic dosage, will be available.

SUMMARY

The development of bronchographic water-soluble media has been traced in a brief historic review. The constituents of various water-soluble media have been described. The biological effect of these media has been discussed, and their controversial aspect with regard to the production of granulomatous changes in the lungs has been analyzed. The technical aspects of bronchography with water-soluble media have been given detailed consideration. The experience of various workers with these media has been outlined. Our own experience with xumbradil viscous B has been described, and the complications thereof analyzed. It has been

concluded that xumbradil viscous B is a safe and satisfactory bronchographic medium. Its use is recommended until other media which are currently being investigated prove to be superior.

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BRONCHOGRAPHY WITH DIONOSIL (PROPYLIODONE)*†

A NEW ABSORBABLE BRONCHOGRAPHIC MEDIUM

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FOR over thirty years, the generally accepted radiopaque medium for bronchography has been iodized oil, such as lipiodol or iodochloral. These compounds are capable of giving excellent bronchograms, are not irritating to the bronchi, and they are of low toxicity. They do, however, possess the great disadvantage of remaining in the lungs for long periods of time. Usually, the iodized oil is coughed up or removed by phagocytosis, but it may remain in the alveoli for weeks or months and interfere with interpretation of subsequent roentgenograms. This is particularly undesirable in tuberculosis, and has limited the usefulness of bronchography in this disease, even though it is now generally accepted that active tuberculosis *per se* is not a contraindication to bronchography.

In recent years, since 1948, a number of attempts have been made to use the soluble contrast media,[8,9] such as diodrast, for bronchography. These compounds, being the same media used for intravenous pyelography and other studies, are safe from the standpoint of systemic toxicity and they are readily cleared from the lungs by absorption into the blood stream. They have the disadvantages, however, of being very irratating to the tracheobronchial tree and of being almost too rapidly eliminated from the lungs. It has been found that the irritation makes it necessary in most cases to limit the studies to one lung, or even, at times, to one lobe. Filming usually must be limited to spot films, as the material usually does not remain in the lungs long enough for large films to be taken. It is now generally felt that diodrast and the similar water soluble media are unsatisfactory for general bronchographic use.[5] Our studies with these agents confirmed these findings, and we abandoned them in favor of the conventional iodized oil. It is usually stated that diodrast and similar soluble compounds produce irritation of the bronchi as a result of the hypertonicity of the concentrated solutions that must be used.[5]

Dionosil is a new contrast medium which overcomes the major disadvantages of both diodrast solutions and iodized oils. This compound is essentially an insoluble form of diodrast, and therefore it lacks the irritating effect of the soluble compounds, while retaining their low systemic toxicity. Dionosil remains in the lungs long enough to allow ample time for satisfactory filming to be done. It is completely absorbed, usually in about four days, so no confusing opaque shadows are left behind in the lungs.

Dionosil has been used extensively in England during the past three years since its introduction there in 1951. A number of reports have appeared in the foreign literature of England, France, Canada and other countries. All have found the material to be satisfactory, and no serious toxic manifestations have been noted. We have used dionosil in fifty consecutive bronchograms at The Johns Hopkins Hospital and the Veterans Administration Hospital, Baltimore, Maryland, with satisfactory results.

DESCRIPTION OF THE MEDIUM

Chemically, dionosil is the normal propyl ester of 3-5-diiodo-4-pyridone-n-acetic acid. Diodrast is the diethanolamine salt of the

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† The Dionosil used in this study was supplied by the Glaxo Laboratories, Ltd., Middlesex, England, through the Picker X-Ray Corporation, White Plains, New York.

same iodine-containing organic acid. The significant difference in the two compounds is that dionosil is essentially insoluble in water, saline, and body fluids, while diodrast is readily soluble. Dionosil is a white crystalline solid, stable under normal conditions. It can be readily sterilized by dry heat, but boiling is not recommended.

Dionosil for bronchography is supplied in two preparations, one an oily suspension and the other an aqueous suspension. The oily medium is a suspension of the dionosil powder in arachis (peanut) oil. The aqueous preparation is a suspension of dionosil in isotonic saline made viscous with the addition of 1 per cent carboxymethylcellulose. Both preparations contain 50 per cent w/v of dionosil. The resulting iodine content is approximately 30 per cent.

The absorption of dionosil from the lungs takes place by hydrolysis of the ester bond. The soluble iodine-containing organic acid is absorbed and excreted by the kidneys in a manner similar to diodrast. Free iodine is not released. When orally ingested, dionosil is readily absorbed and excreted by the kidneys, again without release of free iodine. Consequently, there is no danger of iodism as there is with the iodized oils.

PHARMACOLOGY

The pulmonary and systemic effects of dionosil in animals were studied by Tomich, Basil, and Davis, who originally developed the material at the Glaxo Laboratories.[10] When instilled into the lungs, it produced congestion which reached a maximum in three days and disappeared in two weeks. Histologically, there were a few scattered foci of round cell infiltration which in a few cases persisted for one month. Administration of the aqueous vehicle alone produced the same reaction. In both instances, the changes were not greater than those observed after the instillation of iodized oil, and were much less than the reaction which followed the instillation of diodrast. Oily dionosil produced similar changes. No carboxymethylcellulose or oily vehicle was demonstrated in the lungs five days after administration.

REVIEW OF LITERATURE

Dionosil has been used successfully in England and other foreign countries since 1951. We have been unable to find any report of a fatality or serious reaction. No contraindications other than those which apply to bronchography in general have been reported. No iodism has been reported. In fact, several authors state that iodine sensitivity is not a contraindication. Holden and Crone[4] reported one patient who had an iodine rash following an iodized oil bronchogram of one lung. Two weeks later, he had no reaction following a dionosil bronchogram of the other lung.

Dionosil has been used for bronchographic study of a variety of pathologic conditions in addition to the usual ones, such as bronchiectasis, neoplasm, abscess, and post inflammatory changes. Several series of bronchography in active tuberculosis have been reported, the largest being McKechnie's 144 examinations in 111 patients.[7]

A. *Aqueous Dionosil.* Most of the investigators found the aqueous preparation gave better quality bronchograms than the oily medium. All of their reports mentioned that the aqueous medium tended to adhere to the walls and coat the trachea and bronchi and seldom filled the alveoli. Cummins and Silver[1] found little alveolar filling, even when severe coughing occurred. Don[2] noted that once bronchial coating was obtained, it was difficult to remove by coughing. The medium disappeared rapidly and often the lungs were clear, or nearly so, a few hours after the study. Only occasionally did opaque shadows persist longer than three or four days.

All investigators found the aqueous dionosil to be more irritating than the oily preparation or iodized oil. MacKay and Brodeur[6] and Don[2] found the additional irritation could be controlled by including a small amount of morphine in the premedication. Cummins and Silver[1] found that coughing sometimes made an aqueous dionosil study difficult, and they concluded that the irritation limited the usefulness of this preparation. They did not use mor-

phine premedication. McKechnie[7] had no difficulty with coughing. He used premedication of omnopon and scopolamine.

No immediate reactions to this preparation have been reported, but a transient pyrexia was reported by Don[2] and McKechnie.[7] It usually occurred the day following the examination and was at times accompanied by malaise, headache, loss of appetite and aching in the limbs. It occurred in 12 of 45 patients of Don's series and 67 of 144 patients in McKechnie's series. The highest temperature in Don's series was 100° F. In McKechnie's series, it was over 100° F. in 29 patients. In both series, the duration was about twenty-four hours and seldom more than seventy-two hours. There was no correlation with retention of opaque material in the lungs. No treatment was given and no sequelae were noted. The cause for this reaction was never determined.

B. *Oily Dionosil.* No reactions to oily dionosil have been reported. This includes the febrile reaction observed with the aqueous medium. The reports indicate that the oily preparation is less irritating than the aqueous medium. McKechnie obtained satisfactory studies with omnopon and scopolamine premedication and no local anesthesia of the tracheobronchial tree. Holden and Crone obtained satisfactory results with cocaine 5 per cent local anesthesia and no premedication. In both these studies, the dionosil was administered by cricothyroid puncture. Cummins and Silver,[1] using an intratracheal catheter, found that local anesthesia without premedication gave satisfactory results.

The histologic effect of oily dionosil has been studied in a number of resected lungs. In 4 cases studied by Cummins and Silver,[1] small amounts of retained oil were found in specimens resected a few days after bronchography. In cases resected several weeks after bronchography, only a few droplets of oil were present. In 8 cases examined by Holden and Crone[4] in which pneumonectomy was done, five to twenty days after bronchography, no reaction other than simple phagocytosis was observed.

PRESENTATION OF DATA

In the present series, 50 consecutive bronchograms were performed on 48 patients at The John Hopkins Hospital and at the Baltimore Veterans Administration Hospital. The oily dionosil was used in 24 cases, and the aqueous suspension in 26. There was no selection of cases, and the type of pathology in this group was essentially the same as previously encountered with iodized oil bronchography. There were 14 cases of tuberculosis. Previously, bronchography was rarely done in tuberculosis, because the residual iodized oil confused interpretation of subsequent films. Other diseases encountered in this study were bronchiectasis, carcinoma of the trachea and bronchi, congenital cystic disease of the lungs, and chronic pyogenic abscesses. Both of the dionosil preparations were satisfactory for the study of these conditions. Both preparations gave adequate visualization of the normal bronchi, bronchiectasis, lung cysts, and pyogenic cavities, equal to the visualization obtained with iodized oil. As was expected, tuberculous cavities failed to fill.

TECHNIQUE

The technique employed was identical to that which we had previously used for iodized oil bronchography. It consisted of premedication with barbiturate, atropine, and morphine, local anesthesia of the upper respiratory passages with xylocaine, 8 cc. of a 1 per cent solution administered by nebulization, and injection of the contrast medium through an intratracheal catheter under fluoroscopic control. As a rule, all segments of both lungs were filled. Filming consisted of spot films as indicated during fluoroscopy, and upright posteroanterior and oblique films after both sides were filled. Afterwards, the patient was told to cough up the material as desired. No postural drainage was used.

The technical quality of the examinations equalled those obtained with iodized oil. The exposure factors were the same. We did not find it necessary to alter the technique because of the lower iodine content

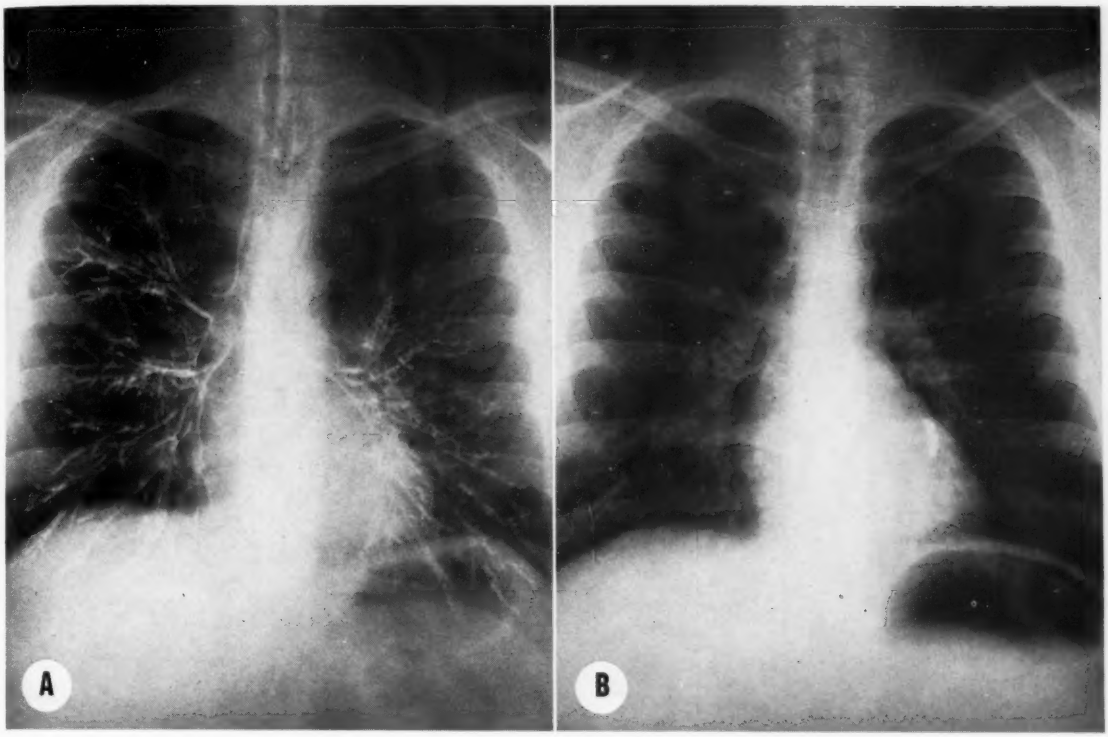

Fig. 1. (*A*) Normal aqueous dionosil bronchogram showing coating of the bronchi, and essentially no alveolar filling. (*B*) Follow-up film four days later showing complete clearing of medium except for a small amount in one of the left basilar segments.

of the dionosil. In 1 case, lipiodol was used on one side, and dionosil on the other, with no detectable qualitative difference in the two sides. In 3 cases which had previous lipiodol bronchograms, comparison of the films revealed essentially no difference in the dionosil and lipiodol studies.

A. *Aqueous Dionosil.* In the 26 examinations performed with aqueous dionosil, the bronchograms obtained were equal to, and sometimes superior to, those obtained with iodized oil. Frequently, but not always, the dionosil would coat the walls of the bronchi (Fig. 1). Alveolar filling occurred occasionally, but much less often than with iodized oil, or oily dionosil. This was true even when coughing occurred. Aqueous dionosil was found to flow somewhat more slowly in the bronchi than the oily suspension or iodized oil, and a slightly longer time was required to assure filling of the distal bronchial segments. The aqueous suspension was slightly more irritating than the oily suspension, but with the use of morphine premedication, this was insignificant.

B. *Oily Dionosil.* In the 24 examinations performed with oily dionosil, the bronchograms were of excellent quality, and very similar to those obtained with iodized oil (Fig. 2). As a rule, it did not coat the walls of the bronchi. Alveolar filling usually occurred to a greater or less degree, depending on whether or not the patient coughed. Occasionally, the coughing would cause flooding of the alveoli.

This preparation was essentially not irritating and was about equal to iodized oil in this respect. In 1 case, no coughing resulted from bilateral filling of the bronchi by injection of a bronchopleural fistula, although the patient had received no preliminary sedation or anesthesia (Fig. 3).

REACTIONS

The majority of the patients withstood the procedure without any adverse effects, and all of those who previously had had iodized oil bronchograms stated that they

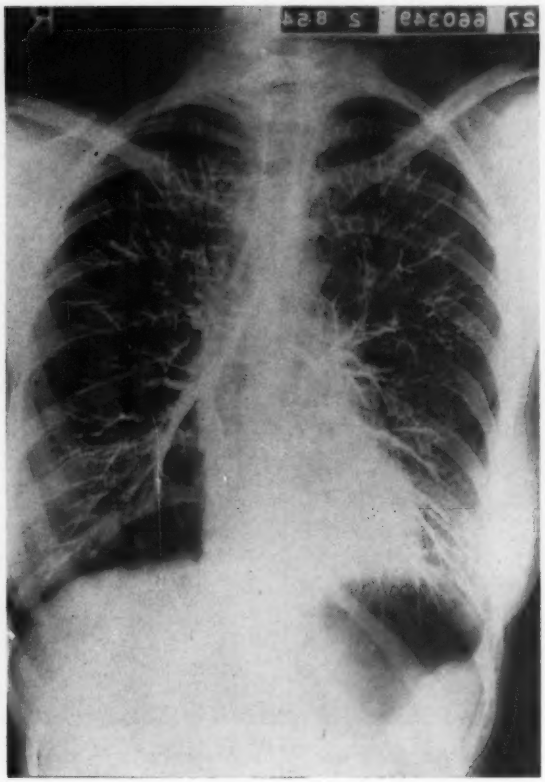

Fig. 2. Normal oily dionosil bronchogram.

Fig. 3. Bilateral bronchogram following injection of bronchopleural fistula with oily dionosil. No coughing occurred. The patient had received no preliminary sedation or local anesthesia. This illustrates that the oily dionosil is not irritating to the tracheobronchial tree.

preferred dionosil because it was free of the unpleasant taste and odor. No sensitivity to the drug and no iodism occurred. No pulmonary infiltration or activation or preexisting pulmonary disease was observed during the period of this study, which amounted to a follow-up time of one to three months. In the series of tuberculous patients, the study produced no detectable influence on the course of the disease. In 2 patients, immediate reactions of difficulty in breathing and minimal cyanosis were observed. One patient was a thirty-one year old adult with moderately advanced tuberculosis who had some shortness of breath and minimal cyanosis for about two hours after the examination. It was believed that this was largely due to the rather marked depression which he developed from the premedication of morphine grains 1/6 and scopolamine grains 1/150. He recovered uneventfully within a few hours without benefit of any specific therapy. The other immediate reaction was in a sixty-five year old man with a history of a palliative lobectomy for carcinoma of the lung five years previously, who had rather marked emphysema in the residual lung fields. He developed air hunger and cyanosis immediately after the examination. He recovered promptly with the administration of aminophylline and oxygen. Both cases were examined with aqueous dionosil.

A late reaction of fever twenty-four to forty-eight hours after the examination was observed in 8 of 38 patients in whom a follow-up was available. Five were examined with oily dionosil and 3 with aqueous dionosil. In some cases, the fever was accompanied by generalized malaise and generalized aches and pains. The longest duration was three days in one patient. The highest temperature was 102° to 103° F. in 3 patients. All recovered without specific therapy.

As a control, 30 consecutive iodochlorol bronchograms were reviewed. One febrile

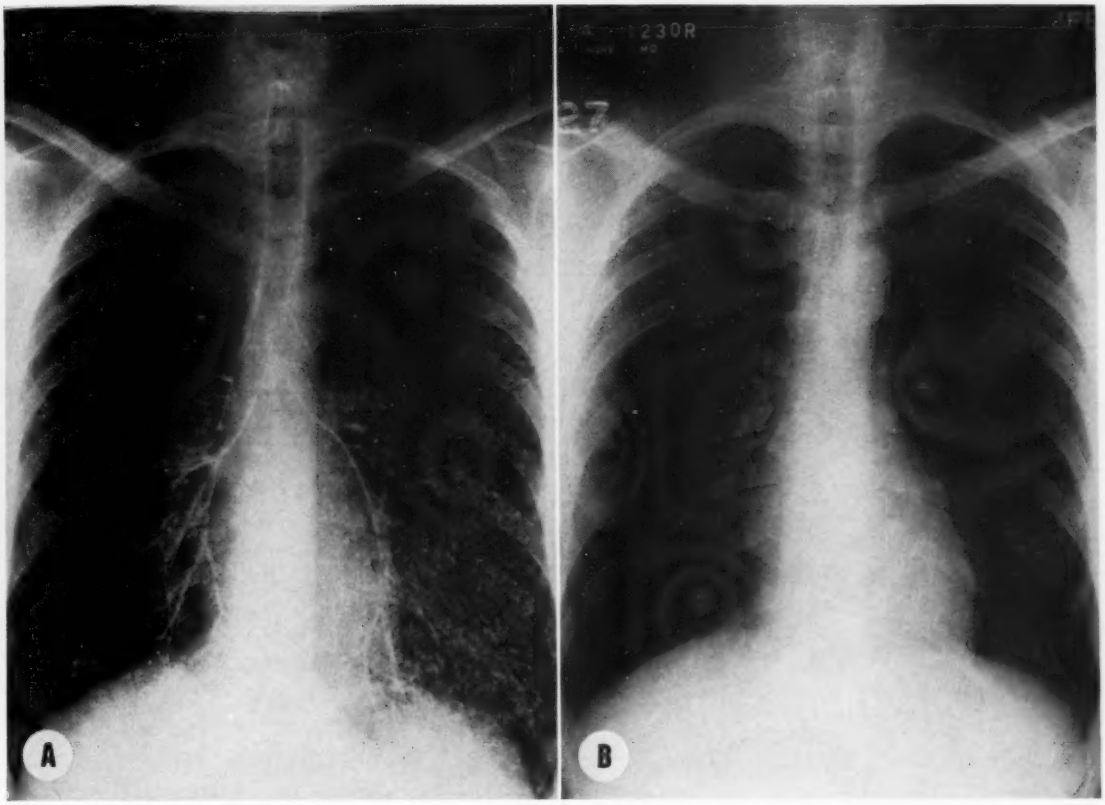

FIG. 4. (*A*) Alveolar filling following bronchogram with oily dionosil. (*B*) Follow-up film four days later showing complete clearing.

reaction of a temperature of 101° F. beginning one day after the examination and lasting for twenty-four hours was observed. No other reactions were recorded.

CLEARING OF THE MEDIUM

In 32 cases, follow-up films of the chest were obtained. Usually, there was complete clearing of the opaque material within four days (Fig. 4). Very often, almost all of the opaque material was coughed up on the first day, and the residual areas of density gradually faded away. A few cases showed flecks of opaque material persisting in portions of the lungs for as long as two weeks. Frequently, residual flecks of material were present only in diseased segments of the lungs, with complete clearing in the normal lung on the follow-up films made in the first three or four days. In 1 case, a pyogenic abscess cavity remained outlined for seven days while complete clearing of the normal lung took place in four days. In another case, the material was still visible in small congenital cysts one month after the examination.

It appeared that most of the material was coughed up. This was well illustrated by 1 case (Fig. 5) which showed complete clearing of the lungs in twenty-four hours except for one of the basilar segments of the left lower lobe which remained completely filled with dionosil. This segment appeared somewhat atelectatic; so bronchoscopy was performed. A mucous plug was removed, following which the segment re-expanded, and the opaque material was then rapidly eliminated.

DISCUSSION

The bronchograms obtained with both the aqueous and oily suspensions of dionosil were of excellent quality. The iodine content of 30 per cent appeared to be entirely adequate. The properties of the oily dionosil with respect to bronchial filling were

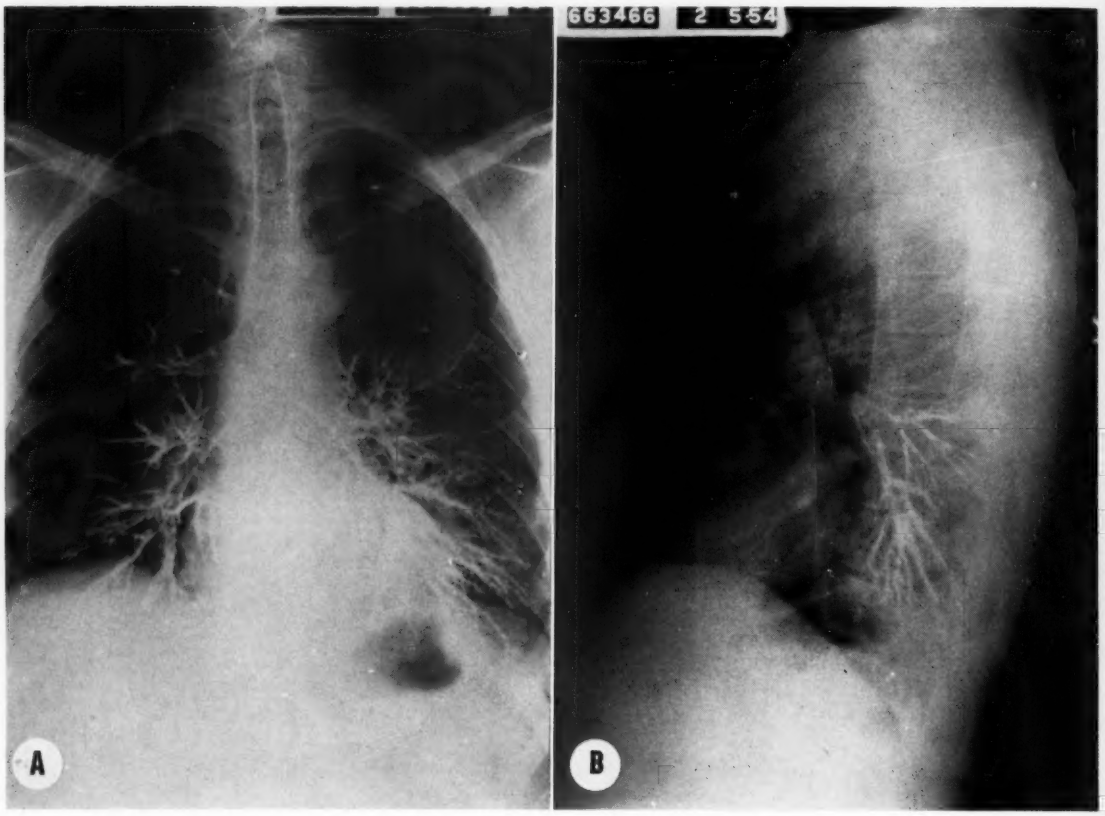

Fig. 5. (*A*) Bronchogram with aqueous dionosil. Apparently normal. (*B*) Follow-up film twenty-four hours later revealing lungs clear except for the left posterior basilar segment. A mucous plug was removed from this segment at bronchoscopy, following which complete clearing occurred. This case illustrates that the greater portion of the dionosil is removed by being coughed up.

very similar to iodized oil, except that the slightly lower viscosity of the oily dionosil made it easier to inject. This same property made alveolar filling more likely to occur, but this was a minor disadvantage, since the material cleared rather rapidly from the alveoli. The higher viscosity and higher surface tension of the aqueous suspension made this preparation a little more difficult to instill, but this disadvantage was offset by the lack of alveolar filling and the tendency of the material to coat the walls of the bronchi. For general use, we believe the aqueous solution is preferable.

We have no explanation for the febrile reaction that occurs with dionosil. It was interesting that this reaction was observed in 5 of our cases examined with oily dionosil, since others have reported it only with the aqueous material. Since it is a transient and apparently harmless reaction, requiring no therapy, we do not regard this as a contraindication to the routine use of dionosil. We do believe that care should be exercised in examining emphysematous patients, and that heavy sedation should be avoided, especially when aqueous dionosil is used. However, morphine, 1/6th grain, is usually necessary in the premedication.

The fate of the oily and aqueous vehicles in the lungs has not yet been conclusively determined. Up to the present time, the evidence, which includes three years experience with the preparation in England, indicates that there are no long-term reactions to either the peanut oil or the carboxymethylcellulose. A final answer on this point cannot be given until a larger number of patients have been followed for a longer period of time.

SUMMARY

1. Dionosil is a non-irritating absorbable bronchographic medium. It is an insoluble iodine-containing compound, closely related in its chemical structure to diodrast. It is supplied in both an aqueous and oily suspension.

2. Aqueous dionosil frequently coats the walls of the bronchi and usually does not fill the alveoli. The oily suspension will fill the alveoli similar to iodized oil. In general, the aqueous suspension is preferable.

3. Dionosil is completely cleared from the lungs, usually in four days. The material not coughed up is absorbed and excreted by the kidneys. Free iodine is not released.

4. Oily dionosil is no more irritating than iodized oil. Aqueous dionosil is slightly irritating, but with morphine premedication, this can be controlled.

5. No iodism or other serious reactions have been observed. A transient pyrexia may follow the study. This requires no treatment and will spontaneously disappear without sequelae.

6. Dionosil is preferable to iodized oil for routine general use in bronchography.

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FRIEDLÄNDER'S PNEUMONIA*

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THE roentgenologist plays a key role in the recognition of Friedländer's pneumonia and in the resultant care of patients in either the acute or chronic stage. There are certain roentgenographic appearances which, combined with a knowledge of the history, physical and laboratory findings, should suggest the diagnosis in the majority of cases. An early diagnosis is important in acute cases, so that prompt institution of correct antibiotic therapy can be commenced. Accurate diagnosis of the chronic cases is important to prevent the patient being labelled as tuberculous, and also to recognize the fact that he may be prone to develop exacerbations of acute Friedländer's pneumonia.

In 1882 Friedländer[9] first described the organism which now bears his name by cultivating it from lungs of patients who had died of pneumonia. He considered it the etiologic agent in most cases of pneumonia. Four years later Fraenkel[8] and Weichselbaum[20] described the pneumococcus and established it as the etiologic agent in lobar pneumonia. Consequently, for many years Friedländer's bacillus was thought to be only a secondary invader. It is now recognized that a definite, but small number of pneumonias are due to Friedländer's bacillus, figures of 1.6 and 2.5 per cent being mentioned.[1,4,11] In recent years, Solomon[19] described the clinical features noting its predilection for males in the later decades of life. About 50 per cent of his cases were alcoholics. An upper lobe was involved in 82 per cent. He stressed the tendency of the disease to progress to a chronic stage with cavities, which may be mistaken for tuberculosis. In 1943, Hyde and Hyde[11] reviewed the findings in 51 patients. In most the onset was sudden, with cough, sputum and chest pain. The blood culture was positive in 45 per cent and the mortality rate for this group was 82 per cent as compared to 23 per cent for the nonbacteremic patients. Pleural effusion occurred in 17 per cent and empyema in 6 per cent. At that time sulfonamide drugs were considered to be of only questionable value in most of the acute cases. In the group of patients reported by Wylie and Kirschner[23] in 1950, there was a large number with antecedent history of alcoholism, diabetes or chronic pulmonary disease. They noticed a decrease in the mortality rate of acute cases, due to the use of newer antibiotics, streptomycin being considered the drug of choice. They suggested that an increasing number of cases entering the chronic suppurative phase may require lobectomy or pneumonectomy for cure.

About the earliest account of Friedländer's pneumonia in the roentgenologic literature was a report by Westermark[21] in 1926. He described a case of apical pulmonary disease with fibrosis and cavity formation which was followed for six months and thought to be tuberculosis. At autopsy there was no tuberculosis present, and Friedländer's bacilli were obtained from the lung. In 1928, Kornblum[12] described the roentgen features of Friedländer's pneumonia and divided it into stages of bronchopneumonia, lobar pneumonia, abscess formation and a chronic stage. Ritvo and Martin[16] more recently discussed the clinical and roentgen features of the disease. They divided the cases into three groups, based upon roentgen appearances. These were the massive lobar consolidation type, the lobular consolidation type, and the chronic form characterized by lung abscess formation and pulmonary suppuration. Bulgrin[3] described a case of

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acute Friedländer's pneumonia and septicemia which was revealed roentgenographically as two well-defined nodular densities, 2 cm. in diameter, in the peripheral portion of the left upper lobe. Following recovery from the pneumonia, the shadows completely disappeared. Felson and his coworkers[7] considered that certain roentgen features, when present, should suggest the diagnosis of acute Friedländer's pneumonia. These are: bulging fissures, sharp margins of the advancing border of the pneumonic infiltrate, and early abscess formation. In addition they stated that, while an unusually dense consolidation was often seen in Friedländer's pneumonia, other types of pneumonia frequently cast shadows of similar density, and they felt that the finding of an unusually dense shadow was of little differential value.

BACTERIOLOGY

Friedländer's bacillus is a member of the bacterial group *Bacillus mucosus capsulatus*. It is also known as *Klebsiella pneumoniae*. Its usual habitat is the respiratory tract of men and certain animals, where it usually leads a parasitic existence. It is occasionally encountered in the nasopharynx. It is said to occur in the upper respiratory tract of 2 to 25 per cent of healthy people. The organism is a short, gram-negative bacillus, surrounded by a thick capsule. It is a straight, thick rod, with parallel sides, but may be slightly ovoid. It is usually seen in the diplobacillus form. It is non-motile and non-spore-forming. There is a profuse mucoid growth on solid media and it ferments carbohydrates with formation of gas and acid. There are three main serological types, *A*, *B* and *C*, and a mixed group: *X*, as shown by agglutination, absorption and precipitin tests. Specific type antisera have been produced. The activity of the sera appears to be a function of the capsule, since, if the bacteria are deprived of their capsule, they lose their specificity and agglutinate equally with sera prepared against any type.[22]

CLINICAL FINDINGS

This study is based on twenty cases of Friedländer's pneumonia seen at the Toronto General Hospital during the past thirteen years (Table I). Nineteen of these were acute and one was chronic when first encountered. There were many other cases, not included in the latter group, where Friedländer's bacillus was grown from sputum but where there was insufficient evidence to consider it as the primary pathogen. In a two and one half year period at our hospital, Oille and Thomas[14] encountered 25 such patients. Eighteen of these had chronic pulmonary disease of one type or another. Bronchiectasis was present in 6 cases, chronic bronchitis and bronchial asthma in 3 each. Tuberculosis, silicosis and diffuse pulmonary fibrosis were seen in the others.

In the present series seventeen patients were males, and 3 were females. The age of the patients ranged from thirty-three to eighty-four years, the average age being 58.8 years. It is interesting to note that the 3 females in the group were aged thirty-seven, thirty-eight and fifty-one, respectively, an average of forty-two years, whereas the average age of the males was 61.7 years. Of the 19 acute cases, the onset was sudden in 8 and gradual in 9, often beginning as a cold or sore throat in the latter group. In 2 cases the onset of the pneumonia was not recorded, the patients having been admitted because of alcoholism and diabetes (Cases VII and VIII). The duration of symptoms before admission varied from one day to four weeks, the average being eleven days. Cough, pleurisy and fever were the initial symptoms most frequently encountered. Malaise, chills and shortness of breath were described less often, while sore throat, cyanosis and weakness occasionally occurred. In those cases surviving the acute pneumonia, the admission leukocyte counts ranged from 6,400 to 27,000, the average being 14,500. One fatal case had a leukocytosis of 56,000. This patient also had myelogenous leu-

TABLE I

SUMMARY OF CASES

Case No.	Patient	Sex	Age	Stage	Type of Involvement	Site of Lesion	Status of Fissures	Abscess Formation	Outcome	Past History
I	M.T.	m	62	Acute	Lobar	R.U.L.[1]	Straight	?	Died (no autopsy)	Alcoholism
II	S.W.	m	56	Acute	Lobar	L.L.L.	?[2]	No	Died (autopsy)	Good health
III	E.W.	m	84	Acute	?[2]	?	?	?	Died (no autopsy)	Myeloid leukemia
IV	D.S.	m	64	Acute	?[3]	L.L.L.	?	?	Recovery	Good health
V	P.K.	m	58	Acute	Segmental	R.U.L.	No change	Yes	Recovery with fibrosis and cavitation	Chronic bronchitis
VI	E.G.	m	33	Acute	Lobar	R.U.L.	Convex down	Yes	Recovery with fibrosis	Chronic bronchitis
					Lobular	L.L.L.	Uninvolved			Pneumonia
VII	T.S.	m	60	Acute	Segmental	R.L.L.	No change	No	Recovery with fibrosis	Alcoholism
VIII	L.W.	m	61	Acute	Confluent lobular	R.U.L.	Convex down	No	Recovery with fibrosis and cavitation[4]	Chronic bronchitis, diabetes
IX	H.C.	m	77	Acute	Lobular	R.L.L.[5]	No change	No	Recovery with fibrosis	Chronic bronchitis
					Lobular	L.U.L.[6]	Convex down	No	Recovery with fibrosis	
X	S.B.	m	78	Acute	Confluent lobular	R.U.L.	Convex down	No	Remaining airless lung	Good health
XI	H.H.	m	50	Acute	Segmental	R.U.L.	Convex down	Yes	Died (no autopsy)	Alcoholism
XII	B.D.	f	37	Acute	Lobar	L.L.L.	Displaced down	Yes	Recovery with fibrosis and cavitation	Bronchiectasis
					Lobar	R.M.L.	No change			
					Segmental	RU.L.	No change			
XIII	A.G.	m	50	Acute	Lobar	R.U.L.	No change	Yes	Recovery with fibrosis	Diabetes, peptic ulcer
XIV	A.W.	m	65	Acute	Confluent lobular	R.U.L.	Slight elevation	No	Complete recovery	Chronic bronchitis Bronchial asthma
XV	V.R.	m	68	Acute	Solitary abscess	L.U.L.	Uninvolved	Yes	Recovery with fibrosis	Diabetes
XVI	W.D.	m	46	Acute	Segmental	R.U.L.	No change	Yes	Recovery with fibrosis	Chronic bronchitis, dumping syndrome
					Lobular	R.M.L.				
					Lobular	L.U.L.				
XVII	M.M.	f	38	Acute	Lobar	R.U.L.	Elevated	No	Complete recovery	Alcoholism
XVIII	M.D.	m	68	Acute	Lobar	R.U.L.	Confex down	Yes	Recovery with marked fibrosis	Previous gastric ulcer, anemia
XIX	N.S.	f	51	Acute	Lobular	R.U.L.	Uninvolved	No	Recovery with minimal fibrosis	Bronchial asthma, diabetes
					Lobular	L.U.L.	Uninvolved			
XX	W.W.	m	70	Chronic	Lobar	R.U.L.	Displaced up	Cavitation	Died (no autopsy)	Pneumonia 20 years before
					Lobar	L.U.L.				

[1] Fluoroscopic observations only.
[2] No roentgenographic information.
[3] Only a single posteroanterior roentgenogram was obtained in which no abnormality was present. Clinically the pneumonia was localized to the left lower lobe.
[4] Later died of Friedländer's septicemia.
[5] Right lower lobe pneumonia on first and second admissions.
[6] Left upper lobe pneumonia on third admission.

kemia. The remaining 3 fatal acute cases had white cell counts of only 8,000, 4,000 and 2,000. In the differential smear, the average neutrophil count was 62 per cent in fatal cases, and 80 per cent in the non-fatal cases. The monocyte count averaged 8 per cent in the fatal cases, and 3.6 per cent in the non-fatal cases. The admission temperatures averaged 103.8° F. in the fatal cases, and 102° F. in those who recovered.

The classical type of thick, tenacious, mucoid, brownish sputum was encountered in about a third of the cases. In others it was described variously as yellow, gray, green and blood-streaked. Sputum cultures were obtained in 18 cases and on repeated cultures showed either predominant or exclusive growth of Friedländer's bacillus in all. In the 1 acute case where sputum culture was not done, there was a positive blood culture. Blood culture was positive in only 4 cases, 3 of these being fatal. Only 3 of the 19 patients with acute Friedländer's pneumonia had been in previous good health. The others had one or more chronic debilitating diseases. Seven patients had chronic bronchitis, 2 had bron-

chial asthma and 1 had bronchiectasis. One patient had previously suffered pneumonia. A number of patients had non-pulmonary diseases of long standing. Five were alcoholics, 3 were diabetics. Three had peptic ulcer previously and 1 of these had associated anemia. One (Case III) had chronic myelogenous leukemia.

PATHOLOGY

In the present series of Friedländer's pneumonia, only 1 of the 5 fatal cases came to autopsy (Case II). The patient died the day after admission, and unfortunately roentgenographic study had not been carried out. The left lower lobe, which was the site of lobar consolidation, was described as being larger than normal with rounded-off pleural edges. The pleura over the lobe was covered by a flaky, fibrinous exudate which gave it a distinctly rough, dull appearance. The cut surface of the lung showed the classical appearance of lobar pneumonia. Microscopic appearances were characteristic of lobar pneumonia with encapsulated bacilli present, both intracellularly and extracellularly.

The postmortem findings in this case correspond, in general, with those described by others, notably Olcott.[15] The involvement of the lung in fatal cases is most often lobar, but may be lobular, or a combination of both. An upper lobe is the commonest site for the lesion. The pleural surface is covered by a fibrinous exudate and adhesions begin to form early. Empyema is encountered in 6 to 30 per cent of cases,[11,23] although it occurred only once in the present series (Case XII). Olcott did not mention a change in lobe volume in any of the 6 cases described by him. The cut surface is usually smooth and uniform, gray or red in color, and shows the gross features of lobar or lobular pneumonia. A mucinous or mucopurulent material may be expressed from the parenchyma and bronchi. Lung destruction may progress to formation of huge cavities, with sloughing of large segments of lung. Wylie and Kirschner[23] described large sloughs of necrotic lung which were picked out of the chest in performing drainage thoracotomies in the acute phase. In cases which had lobectomy for recurrent episodes of Friedländer's pneumonia there were marked pulmonary fibrosis, multiple abscess formation and densely adherent and thickened pleura. Microscopically, in the acute stage the alveolar walls are congested and swollen. The alveoli are filled with an exudate composed of polymorphonuclear and mononuclear cells. Often the latter predominate. Bacilli are found in the alveoli and may be present in enormous numbers. Phagocytosis by the polymorphonuclear and mononuclear cells results in many of the bacteria being demonstrated within these cells. There is often necrosis of alveolar walls, which leads to destruction of parenchyma and abscess formation.

ROENTGENOGRAPHIC FINDINGS

Roentgenograms were obtained in 16 of the 19 cases of acute pneumonia and in the single case of chronic pneumonia. The cases without roentgenograms were the first 3 of this series and were all fatal. Fluoroscopic observation was recorded in Case I, and autopsy description of the lung is available in Case II. Case IX had three separate admissions for acute Friedländer's pneumonia, twice in the right lower lobe and once in the left upper lobe. In 5 cases, there were two or more lobes involved simultaneously and in 4 the lesions were bilateral. The upper lobes were by far the commonest site of disease, being involved nineteen times, fourteen in the right upper lobe and five in the left upper lobe. In only 10 instances were other lobes involved (Table I).

The actual roentgenographic appearance of the pneumonic lesion does not differ markedly from that of other types of pneumonia, although there are certain distinctive features which are demonstrated frequently enough to suggest the diagnosis whenever these are encountered. The appearance depends to some extent on the duration of the disease before initial roent-

genograms are obtained. The onset of consolidation is early and it usually extends rapidly to involve all or the greater part of one or more pulmonary segments. Occasionally multiple poorly defined foci of bronchopneumonia persist and may or may not become confluent. In the acute cases of the present series, the consolidation in the lobe was complete in 7 instances, segmental in 6, lobular in 8, confluent-lobular in 3, and in 1 the appearance was that of a solitary lung abscess. The lesion usually extends rapidly to one or more pleural surfaces. An interlobar fissure forms one boundary of the consolidation in many cases. In the 13 instances of acute pneumonia where the consolidation involved an upper lobe, and extended to a fissure, 6 showed downward convexity to the major fissure or to adjacent portions of major and minor fissures. In 5 the fissures were in normal location, and in 2 of the 13 cases the fissure was elevated. In the 2 cases with lower lobe consolidations which extended to the major fissure, the fissure was in normal location in 1 and was depressed in the other. The latter patient (Case XII) had previous bronchographic demonstration of bronchiectasis with diminution of left lower lobe volume. Mediastinal shift was not a feature of any case in the present series except in 1 patient who had right upper lobe pneumonia with depression of major and minor fissures, where the trachea was shifted slightly to the side of the consolidation. While pleuritic type of chest pain is a common symptom, actual pleural thickening or fluid is rarely demonstrated roentgenologically in the acute phase. This is due to the marked density of the large volume of underlying airless lung. As the disease abates and resolution begins, partial re-aeration of the lung allows demonstration of pleural thickening which may remain long after recovery from the acute stage. The thickening varies from a few millimeters to two or more centimeters.

Necrosis of lung tissue with "breakdown" and abscess formation may occur relatively early in the acute phase. Of the 15 acute cases in which roentgenograms were obtained, one or more abscess cavities were demonstrated in 8, in 6 of which they were present in the initial roentgenograms. The abscesses were usually multiple. The cavities were most often small, measuring from 0.5 to 2.0 cm. in diameter. In Case VI, the cavity was huge and measured 14.0 cm. in greatest diameter. Frequently the initial roentgenogram shows a picture of multiple small, rounded abscess cavities. Serial follow-up films often demonstrate coalescence of many of these to form larger abscesses, possibly replacing the greater part of a segment. The inner lining of the abscess cavities is smooth and regular. As resolution begins, the consolidated lung re-aerates, rendering visible portions of the outer walls of the adjacent abscesses. The actual abscess wall varies in thickness from a few millimeters to a centimeter. Many of the abscesses are peripherally located, and the outer wall seems to be formed by thickened pleura. Gross pleural effusion was seen in one case, following rupture of an abscess cavity into the pleural space, producing a pyopneumothorax. From this stage healing, as shown on roentgenograms, is a very gradual matter, covering many months and usually leaving some permanent scarring. The abscess cavities may either persist, and as their walls become thinner take on the characteristics of thin-walled blebs, or they may appear to completely obliterate themselves. In these cases bronchography may demonstrate persistence of small cavities communicating with the bronchus. Considerable parenchymal fibrosis is an almost constant sequela and serial examinations often show progressive diminution of lobe volume, with shift of fissures, hilus and mediastinum in the direction of the fibrotic area. Some pleural thickening usually remains.

The picture is now that of chronic Friedländer's pneumonia. Bronchography in the chronic phase may show clumping of bronchi, indicating decreased lung volume. Bronchiectasis of varying degrees may be demonstrated. Collections of contrast sub-

stance may gather in parabronchial cavities, indicating the sites of previous abscesses. It is not uncommon to encounter considerable difficulty in getting the opaque material to enter the bronchi of the involved contracted lobe.

DIFFERENTIAL DIAGNOSIS

There are no pathognomonic roentgen diagnostic signs of Friedländer's pneumonia and a knowledge of the history, physical and laboratory findings are helpful adjuncts in suggesting a diagnosis. It follows, therefore, that the exclusion of other conditions must be based upon clinical-roentgenographic findings.

Pneumococcal and other lobar pneumonias can produce identical appearances on initial roentgenograms. Multiple small translucencies at this stage probably indicate abscess formation, and favor the diagnosis of Friedländer's pneumonia. Likewise the curving of an interlobar fissure away from the lesion suggests Friedländer's pneumonia. Lobar pneumonia in a young person, previously healthy, is more likely to be due to some organism other than Friedländer's bacillus. Leukocytosis and fever on the average tend to be lower in Friedländer's pneumonia. The characteristic chocolate-colored tenacious mucoid sputum favors the latter, but is present in less than half of the cases. With modern methods of treatment, pneumococcal pneumonia usually shows striking roentgenographic evidence of resolution in a week, leaving little or no residue in the lung. Failure of such resolution in the expected time should suggest the possibility of Friedländer's pneumonia.

Staphylococcal pneumonia is uncommon, except during epidemics of influenza, measles or whooping cough,[5] or secondary to staphylococcal bacteremia. The majority of the patients are in the first decade.[10] The main roentgen features are those of an early diffuse infiltration or multiple rounded lesions, both of which soon break down to cavity formation. In one series,[10] however, only a third of the cases showed abscess. Empyema is common.[17] Streptococcal pneumonia is rare, and usually follows some other infection involving the respiratory tract, such as influenza, measles or acute sore throat. Patients are usually younger than those with Friedländer's pneumonia, and a fifth of the cases are said to occur under the age of ten years.[13] There are no characteristic roentgen features,[18] although the commonest picture is that of multiple patchy consolidations which may coalesce to involve one or more entire lobes. Massive pleural effusion has been described as a characteristic finding, occurring in half to three quarters of the cases.[13] Positive differentiation of Friedländer's pneumonia from the other bacterial pneumonias, however, rests on bacteriologic examination of sputum or blood with identification of the causative organism.

The various virus pneumonias, while presenting no characteristic roentgen appearances, are rarely as extensive as Friedländer's pneumonia, and do not commonly show evidence of abscess formation. The early stage may show perihilar infiltration, and later, poorly defined parenchymal lesions which are frequently bilateral. The lesions are generally more central than those of Friedländer's pneumonia, and do not extend to involve peripheral or interlobar pleura as often. For this reason pleural fluid and thickening are not a common feature. These pneumonias usually occur in younger people who were previously healthy. The clinical and laboratory findings are quite different from those of the bacterial pneumonias. The onset is usually more insidious, and characterized by a retrosternal tightness, rather than pleuritic pain. The leukocyte count is normal or slightly elevated, and there is a rise in the cold agglutinin titer. The differentiation from tumor is occasionally necessary, especially after the acute phase is over, when the roentgen picture is not changing as rapidly. If the patient is examined for the first time at this stage the correct diagnosis may be difficult. The appearance in Figure 8 is extremely suggestive of medias-

tinal tumor. The history is most important in such cases. The gradual re-aeration of the involved portion of lung, with or without the progression of fibrotic change, along with negative bronchoscopic and cytologic findings, should aid in the exclusion of tumor. Examination of the sputum, if the patient has not been receiving antibiotic drugs, may demonstrate the causative organism.

The problem of distinguishing between tuberculosis and chronic Friedländer's pneumonia has been stressed for many years.[6,12,21] The roentgen appearance of the two diseases may be identical (Fig. 15). Both diseases are most common in the upper lobe and can produce marked cavity and bleb formation, and pleural thickening. The fibrosis with contraction of involved lung and displacement of adjacent structures can be similar in each type of lesion. With adequate treatment of patients with acute Friedländer's pneumonia by antibiotic drugs, the incidence of such marked degrees of fibrosis may decrease. However, lesser degrees of fibrosis will occur, and due to its predilection for the upper lobe, chronic Friedländer's pneumonia should be suggested by the roentgenologist if a definite diagnosis of tuberculosis is not established.

REPORT OF CASES

The histories of the following cases selected from the reported series are presented to illustrate the various clinical and roentgenologic features of acute and chronic Friedländer's pneumonia.

Case vi. E.G., male, aged thirty-three, was admitted to the hospital in February, 1949, following eight days of malaise, chills and fever, and bilateral pleuritic pain. He had had pneumonia several times during childhood. He had had a chronic cough with a small amount of yellowish sputum for many years.

Examination showed physical signs of consolidation of right upper lobe and a portion of the right lower lobe. There was slight cyanosis. The temperature was 103°F. The white blood cell count was 27,000. The smear showed 90 per cent neutrophils and 1 per cent monocytes. The sputum was thick and rust-colored and contained large numbers of Friedländer's bacilli.

Chest roentgenograms (Fig. 1) showed the

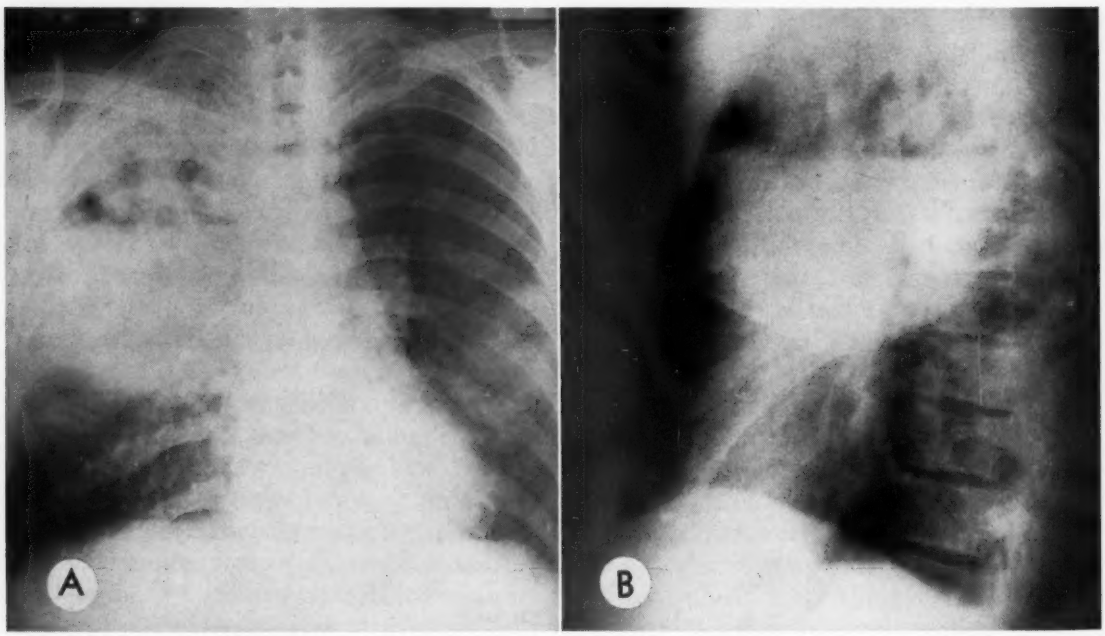

Fig. 1. Case vi. Right upper lobar consolidation with huge abscess cavities, and downward bulging of the adjacent major and minor fissures.

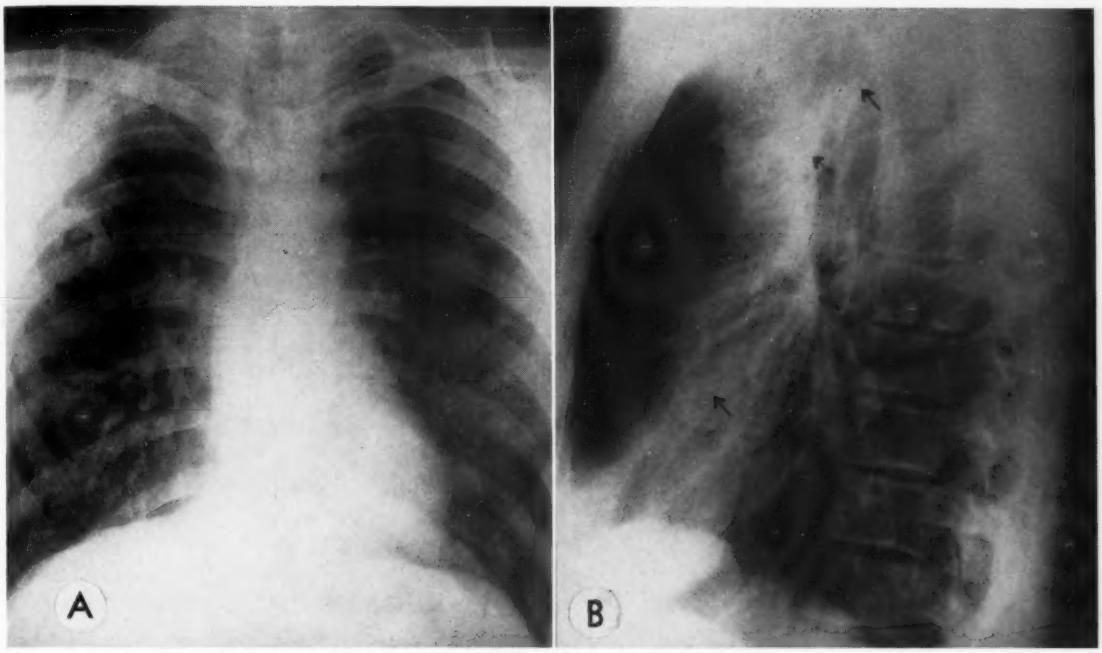

FIG. 2. Case VI. Following rib resection and drainage of abscess. Recovery with fibrosis, with slight shift of trachea to the right, and forward shift of upper portion of major fissure (arrows).

entire right upper lobe to be involved by the pneumonic process. The junction of horizontal and oblique fissures was displaced downward, and the fissure lines themselves were curved with a downward convexity, suggesting an increase in volume of the right upper lobe, although the trachea was not shifted. There was a huge abscess with an air-fluid level measuring 14 cm. in its anteroposterior, and 10.5 cm. in its transverse diameter. There was a small amount of pleural thickening over the lateral aspect of the right upper lobe. A small poorly defined area of pneumonia was present in the posterior basal segment of the left lower lobe.

Streptomycin therapy was begun, but the bacilli rapidly developed a marked resistance to it. Penicillin and aureomycin were ineffectual. Aspiration of the cavity and instillation of antibiotic were of no avail. For this reason, a rib resection and drainage was carried out. Following this the patient's condition gradually improved. Concurrent with the clinical improvement, the abscess cavity gradually became smaller and the consolidation decreased. There was associated increase in the pleural thickening. The gradual disappearance of the abscess cavity was accompanied by a decrease in upper lobe volume with upward migration of fissures and tracheal shift to the right. The right hilus rose to the level of the left and there was some narrowing of intercostal spaces (Fig. 2). It was not until this occurred, that the lesion on the left side began to fade gradually. This was the situation two and one half months after onset of symptoms, at the time of discharge from the hospital.

Roentgenograms obtained four years later showed no further change in right upper lobe volume. There was considerable pleural thickening overlying the upper lobe. Some fibrotic change marked the site of the former left lower lobe pneumonia. Bronchography at that time was only partially successful due to difficulty in filling the right upper lobe bronchi. Mild bronchiectatic dilatation of all upper lobe bronchi was present, but residual cavitation could not be demonstrated.

Comment. This case illustrates the huge amount of lung destruction and cavitation that may occasionally occur. It also shows the bulging of the fissure which is a feature of Friedländer's pneumonia, although it occurs in less than half of the cases. The gradual change from the acute to the chronic phase is well demonstrated, as well

as the progressive fibrosis and decreased lung volume in the well established chronic stage.

CASE XII. B.D., female, aged thirty-seven was admitted to the hospital in June, 1951, following three weeks of fever, cough and right pleuritic pain. She had had pneumonia at the age of five, and rheumatic fever at the age of eleven. She consumed large quantities of alcohol. For many years she had a chronic cough, productive of yellowish-green sputum occasionally blood-tinged. Two years before admission, bronchographic evidence of bronchiectasis was obtained with involvement of lingula and left lower lobe, right middle and lower lobes.

On admission the temperature was 102°F. and the white blood cell count was 20,400 with 89 per cent neutrophils and 2 per cent monocytes. The sputum was very foul, grayish-green in color and grew Friedländer's bacilli on culture.

Roentgen examination on the day of admission showed pneumonic involvement of the left lower lobe, right middle lobe and portions of anterior and posterior segments of the right upper lobe (Fig. 3). Lobe volumes remained normal except for the left lower lobe which was considerably reduced in volume and corresponded to that demonstrated by previous bronchography. The lesions were not homogeneous but showed innumerable poorly defined translucencies varying from a few millimeters to one centimeter in diameter. Penicillin and streptomycin therapy were begun. There was very gradual clinical improvement and temperature reached normal after six weeks.

Roentgen examination one week after admission showed several of the abscess cavities to have increased in size and to contain air-fluid levels. The largest was in the anterior segment of the right upper lobe and measured 5.5 cm. in greatest diameter. Moderate amounts of fluid appeared in each pleural space (Fig. 4).

Over the following weeks there was a reduction in the over-all density of the lesions. Some of the smaller cavities tended to disappear but the larger ones persisted, their walls becoming thinner. One abscess ruptured into the left pleural space, producing a pyopneumothorax (Fig. 5). A pneumoperitoneum was instituted in an attempt to reduce the volume of the abscess cavities. This produced a rather quick clinical improvement but the roentgen appearance changed more slowly. Finally a roentgenogram

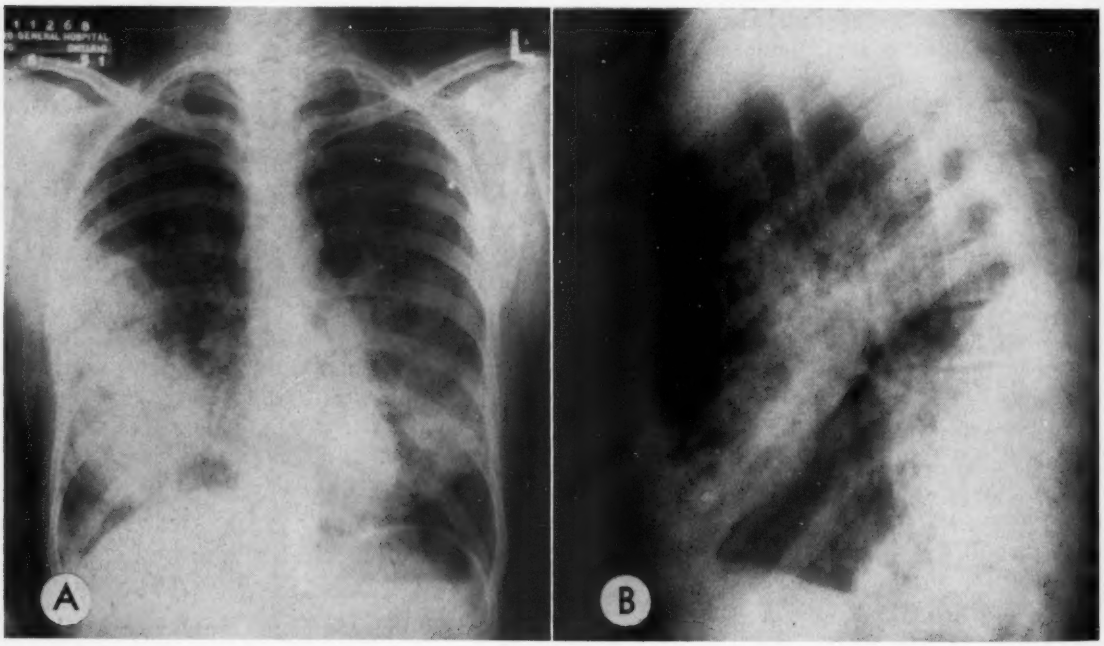

FIG 3. Case XII. Pneumonia involving right middle lobe, anterior and posterior segments of right upper lobe, with early multiple abscess formation, but no shift of major fissure. The consolidation in the left lower lobe reveals a depressed fissure and decreased lobe volume related to previously demonstrated underlying bronchiectasis.

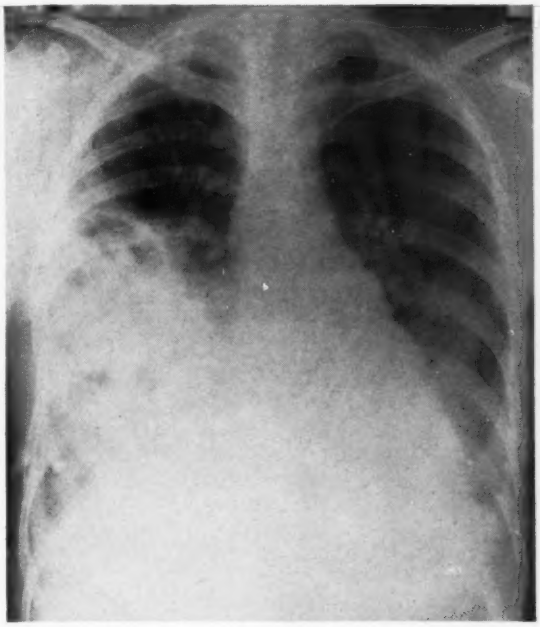

Fig. 4. Case xii. Coalescence of multiple small abscesses to form large cavities.

Fig. 5. Case xii. Perforation of abscess in left lower lobe to form pyopneumothorax. Beginning recovery from the acute stage on the right, with multiple thin-walled cavities persisting.

obtained five months after the onset of illness showed a picture of fibrosis in the portions of previously involved lung with several rounded translucencies, probably representing unobliterated cavities (Fig. 6). At this point the patient became lost to follow-up.

Comment. The occurrence of Friedländer's pneumonia in a lobe, the volume of which is reduced, probably means it was the site of previous pulmonary disease, such as bronchiectasis, which was the underlying lesion in this instance. This case illustrates a common picture of Friedländer's pneumonia, namely, early bronchopneumonic involvement of several segments of lung, particularly portions of anterior and posterior segments of the right upper lobe, with a mottled pattern of airless lung with intervening air-containing areas, some of which coalesced to form large abscess cavities. The final picture is that of a "honeycomb" pattern of fibrosis, with decreased lung volume and intervening thin-walled residual cavities.

Case viii. L.W., a Chinese male, aged sixty-one, was admitted in August, 1949, in a semi-stuporous state. He had had a chronic cough for about fifteen years. He had been a diabetic for an unknown period of time. Physical examina-

Fig. 6. Case xii. Chronic stage, following pneumoperitoneum in an attempt to reduce cavity sizes. Pulmonary fibrosis.

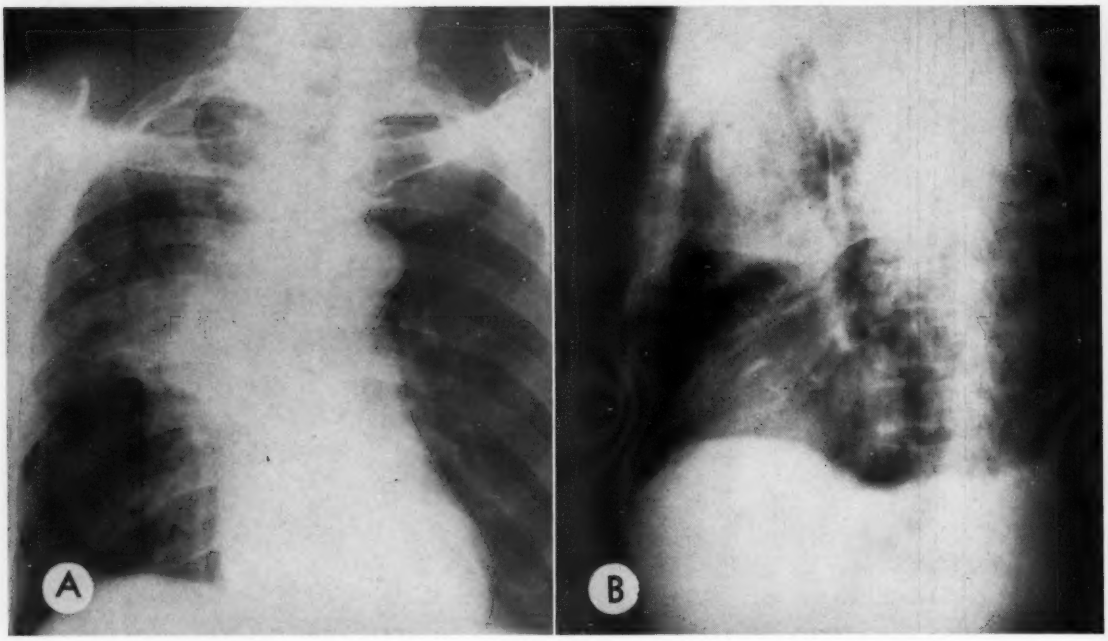

Fig. 7. Case VIII. Acute pneumonia involving anterior and posterior segments of right upper lobe, with downward displacement of upper end of major fissure.

tion showed him to be in diabetic acidosis with dehydration and Kussmaul breathing. The chest was clear. Temperature was 102°F., the white blood cell count was 6,400. Blood sugar was 500 mg. per 100 cc. The carbon dioxide combining power was 36 volumes per cent.

A roentgenogram of the chest showed the lungs to be normal.

Intensive treatment of the diabetes was begun, and because of the fever, penicillin was administered. The temperature rose to 106°F. Four days after admission an area of dullness to percussion was found in the right upper chest. Roentgenograms of the chest (Fig. 7) showed consolidation in the lower portions of anterior and posterior segments of the right upper lobe, limited inferiorly by the minor fissure and the upper portion of the major fissure. The latter appeared to be deflected slightly downward. No definite cavitation was present. There was considerable old pleural thickening in the posterior costophrenic angle on the left side. Blood and sputum cultures demonstrated Friedländer's bacilli, so streptomycin therapy was begun. There was gradual but steady improvement and the temperature reached normal on the seventeenth hospital day. Streptomycin was continued, and finally Friedländer's bacilli were no longer obtained on sputum culture.

Periodic roentgenograms showed resolution of the process in the posterior segment. The lesion in the anterior segment persisted (Fig. 8), becoming sharply defined and of considerable density, but laminagrams failed to show cavitation. At this time the minor fissure was convex downward in its medial portion, producing the so-called "S-curve," usually associated with tumor. This solid lesion maintained its shape but gradually became somewhat smaller and eventually air-containing. Finally the lung in this area appeared as a bleb with a thin, smooth, sharply defined ovoid outline (Fig. 9).

Three months after admission the patient was discharged, clinically well. Six weeks later he was re-admitted with Friedländer's septicemia, to which he finally succumbed despite intensive antibiotic therapy. During the final admission chest films showed only the bleb and the residual fibrosis from the previous pneumonia.

Comment. This case is of interest, because it shows healing in one segment and persistence of disease in another. The latter had the appearance of a solid tumor mass or, in the lateral projection, of an encapsulated pleural effusion. However, periodic follow-

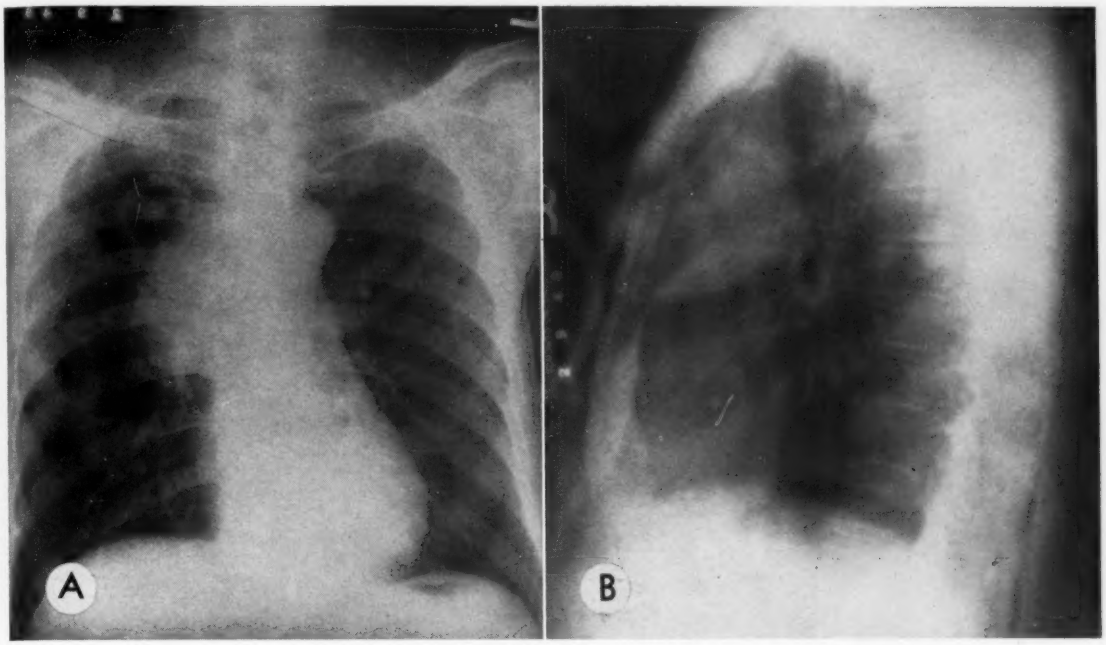

FIG. 8. Case VIII. Clinically recovered from acute stage. Resolution of pneumonia in posterior segment of right upper lobe. Persistence of airless mass in anterior segment with downward bulge of minor fissure. The lesion simulates tumor at this stage.

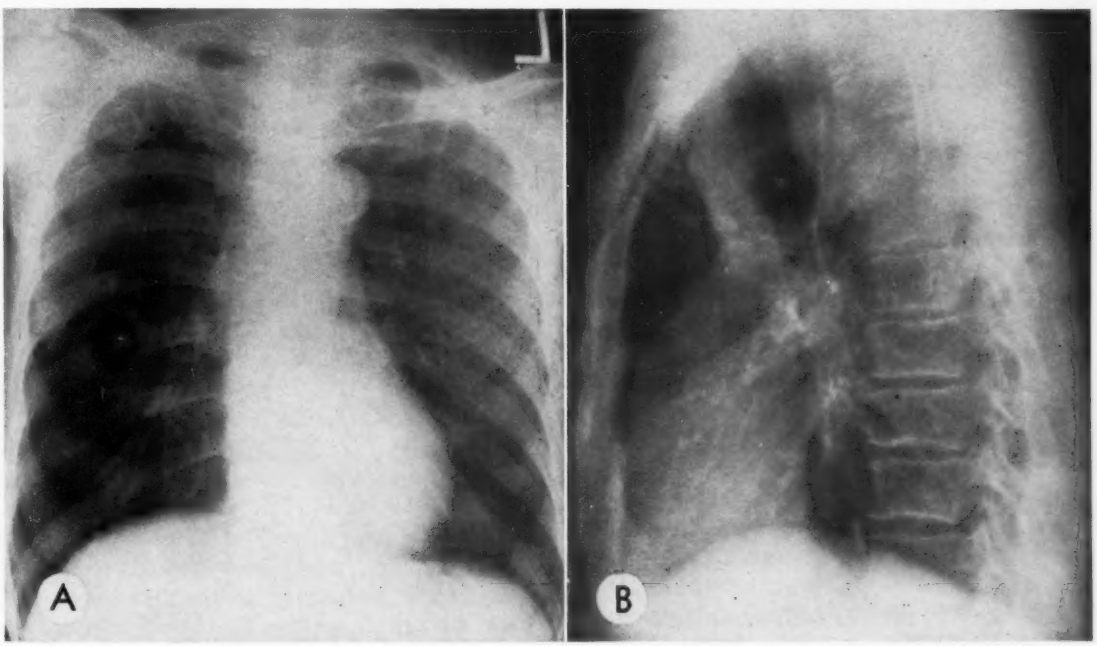

FIG. 9. Case VIII. Final stage with the dense mass replaced by a thin-walled aerated cavity immediately behind the sternum.

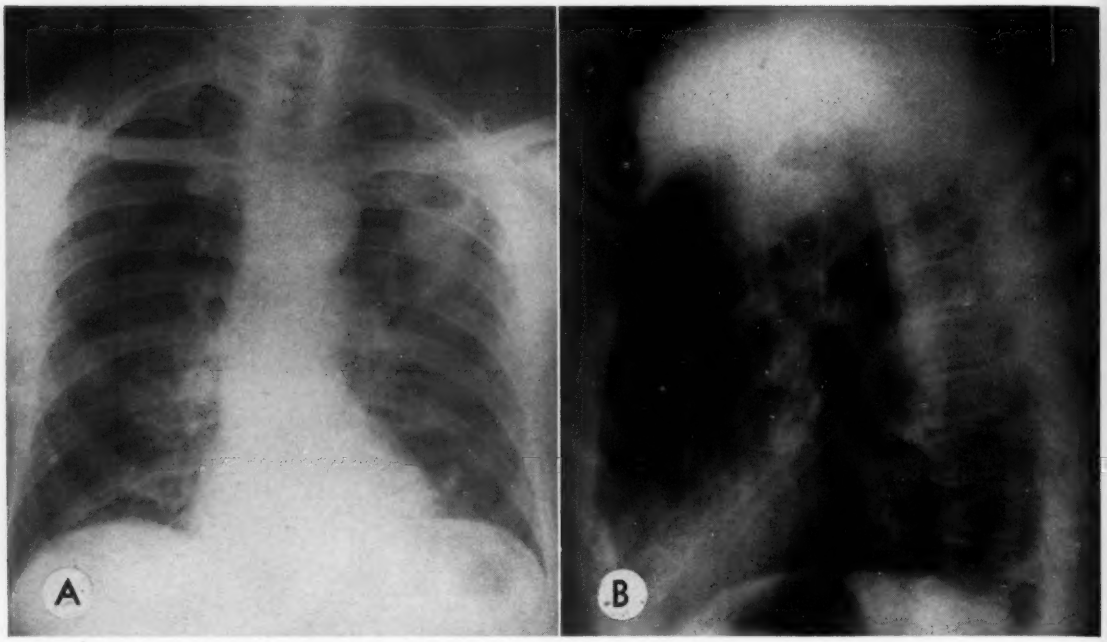

Fig. 10. Case xv. Initial roentgenogram two months after onset of symptoms. Solitary lung abscess with air-fluid level.

up examinations showed gradual re-aeration of the area with a final appearance of fibrosis and bleb formation similar to that of most cases of chronic Friedländer's pneumonia.

Case xv. V.R., male, aged sixty-eight, was admitted to the hospital in August, 1952, following two months of increasing weakness and anorexia. During this time he expectorated a stiff tenacious material that was not blood-streaked. Three weeks before admission he noted a slight tightness in the chest. He had been a diabetic for eighteen years, fairly well controlled on diet and insulin, although on admission his blood sugar was elevated.

Physical examination of the chest was negative. The temperature was 101°F. White blood cell count was 13,100 with 63 per cent neutrophils and 4 per cent monocytes. On admission, blood sugar was 274 mg. per cent. Sputum culture demonstrated Friedländer's bacillus which was senstive to aureomycin.

The cause of the patient's symptoms was not recognized until films of the chest showed a solitary lung abscess in the apical portion of the left upper lobe (Fig. 10). It was rounded, somewhat hazy in outline, and measured approximately 5 cm. in diameter. The lesion extended to the surface of the lung laterally where there was slight pleural thickening. It was a considerable distance from the interlobar fissure. The abscess cavity was 2.5 cm. in diameter with an air-fluid level. The inner wall of the cavity was smooth and sharply defined. The wall of the abscess was 2.5 cm. in thickness.

Aureomycin and dicrysticin were administered and the diabetes was brought under control. During hospital stay the clinical picture improved but the abscess cavity persisted, and for a while the lesion seemed to extend toward the hilus. Slowly, the appearance of the chest improved with a decrease in size of the cavity and gradual re-aeration of the involved lung. He was discharged from hospital five weeks after admission.

Out-patient follow-up roentgenograms over the next two years showed only a few remaining strands of fibrosis with some residual pleural thickening. No evidence of old cavity was demonstrated. There was no recognizable diminution in lung volume (Fig. 11). A bronchogram was attempted but was unsuccessful in demonstrating left upper lobe bronchi. At that time he felt well and had gained weight. There was no cough or sputum.

Comment. Strictly speaking, this case is

not one of Friedländer's pneumonia, but one of solitary lung abscess due to Friedländer's bacillus. Since the symptoms which led to his admission had been present for two months or more it may be presumed that this was a pneumonia with subsequent abscess formation. Once again the final picture was one of pulmonary fibrosis. The initial lesion was small enough, however, that the fibrosis did not cause any appreciable diminution of lung volume.

Case v. P.K., male, hotel porter, aged fifty-eight. The patient was admitted in April, 1947, twenty-four hours after onset of chills and generalized aches and pains. He had sharp right pleural pain and began to cough up rusty-colored sputum. He had had bronchitis for many years.

Examination showed signs of consolidation of the right upper lobe. There was a friction rub in the right axilla. The temperature was 103°F.; the white blood cell count was 12,600 with 76 per cent neutrophils and 2 per cent monocytes. Friedländer's bacilli were found in smears and cultures of the sputum.

Roentgenogram of the chest (Fig. 12) demonstrated pneumonia in the posterior segment and in the adjacent portion of the anterior segment of the right upper lobe, limited inferiorly by the oblique and horizontal fissures.

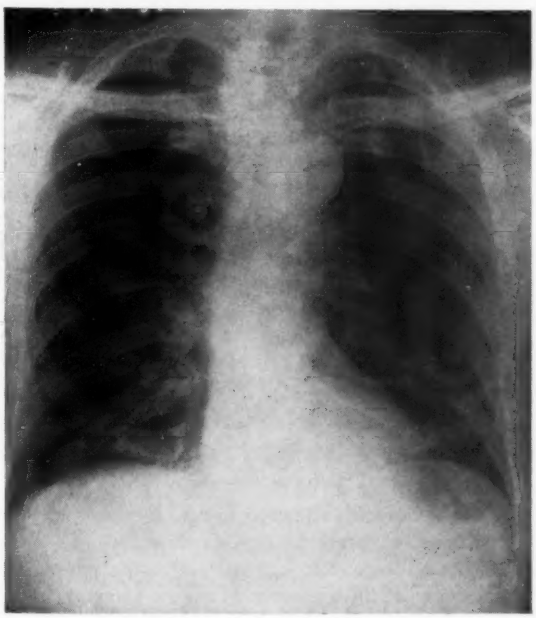

Fig. 11. Case xv. Minimal pulmonary fibrosis.

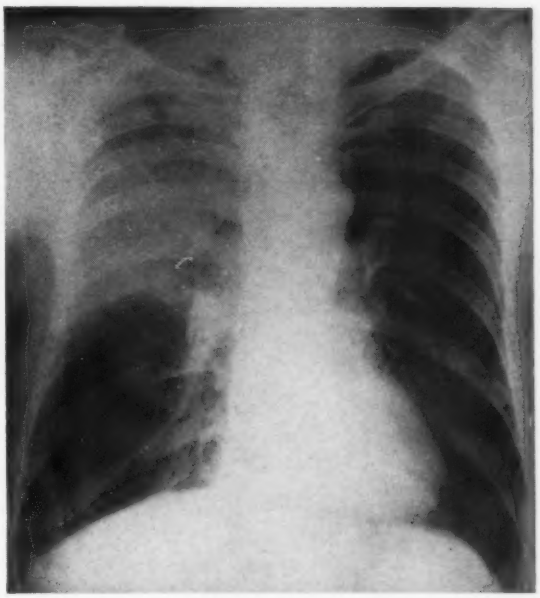

Fig. 12. Case v. Consolidation of anterior and posterior segments of right upper lobe, without fissure displacement. Multiple small translucencies throughout the lesion.

There was no displacement or deformity of the fissures. The lesion faded out gradually into normally-aerated surrounding upper lobe. There was a mottled pattern of translucencies in the involved lung due to multiple small, rounded abscess cavities. Some poorly defined areas of bronchopneumonia were present in the right middle lobe.

Treatment with antibiotics resulted in steady clinical improvement and Friedländer's bacilli could no longer be cultured. Roentgenographic improvement lagged behind the clinical, and the density was slow to clear. Laminagrams confirmed the "honeycomb" pattern of translucencies (Fig. 13). As clearing took place, considerable pleural thickening over the lateral border of the lung was demonstrated. There was gradual upward migration of the horizontal fissure. A bronchogram (Fig. 14) showed multiple saccular cavities throughout the area of previous pneumonia without evidence of significant surrounding reaction. The cavities did not occur in the course of the bronchi, but lay alongside them, communicating with them by short sinus tracks. A roentgenogram obtained six months later showed some obscuring of the lung by old contrast medium. There had been no further shift of the minor fissure or other evidence of progressing fibrosis. At that

Fig. 13. Case v. Laminagram showing the small abscess cavities.

time the patient complained of shortness of breath and cough productive of two cupfuls of white and yellow sputum per day.

Comment. This case is of interest as it shows on both plain roentgenograms and laminagrams multiple small translucencies which might have been interpreted as multiple abscesses, or as areas of aerated lung remaining between patches of bronchopneumonic consolidation. The bronchogram made after recovery from the acute phase shows numerous cavities corresponding more or less to the cavities present during the acute phase. These are not bronchiectatic in the usual sense, as many lie alongside bronchi rather than being enlargements of the bronchi themselves.

Case xx. W.W., male, aged seventy. The patient was admitted to the hospital in November, 1953, because of vomiting for one week and cough without sputum for five days. There was increasing shortness of breath for the past two years. He had had pneumonia several years before.

Examination showed a drowsy, dehydrated, cachectic elderly man. The trachea was shifted to the right. There was decreased movement of the right hemithorax, decreased aeration of the right upper lobe and emphysema in the lower portions of each lung. There was evidence of arteriosclerotic heart disease. The temperature was 100°F.; the pulse was 96 and irregular. The white blood cell count was 6,900 with 53 per cent neutrophils and no monocytes.

Roentgenographic examination (Fig. 15) showed evidence of widespread pulmonary fibrosis, most marked in the upper lobes, particularly on the right side. There were intervening small, scattered, rounded translucencies interpreted as emphysematous areas, varying from a few millimeters to several centimeters in diameter. There were no air-fluid levels. The hili were elevated and the trachea was drawn over to the right. There was considerable pleural thickening over the upper lobes. The lower lobes were emphysematous.

A tentative diagnosis of tuberculosis was made and streptomycin, paraminosalicylic acid and isoniazid were given. Tubercle bacilli could not be demonstrated and tuberculin skin test was negative to one milligram. How-

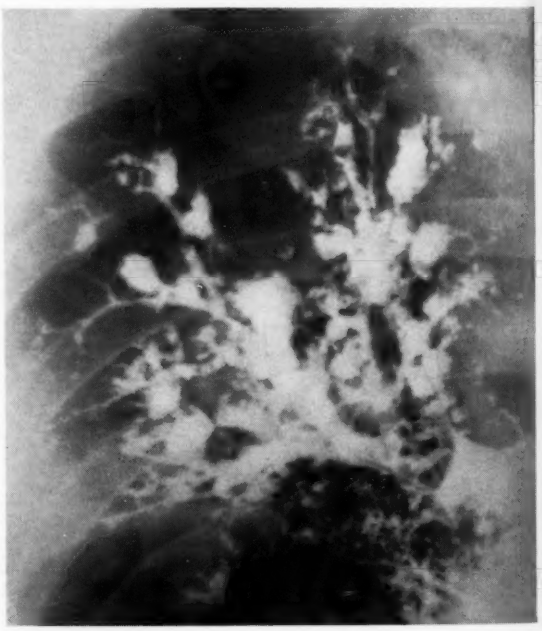

Fig. 14. Case v. Bronchogram following recovery from acute phase. Many of the cavities lie alongside the bronchi, and represent excavations of parenchyma rather than ectatic bronchi. The air-filled cavities shown in Figure 13 superimpose on the contrast-filled cavities of Figure 14 remarkably well, taking into consideration the differences in roentgen technique.

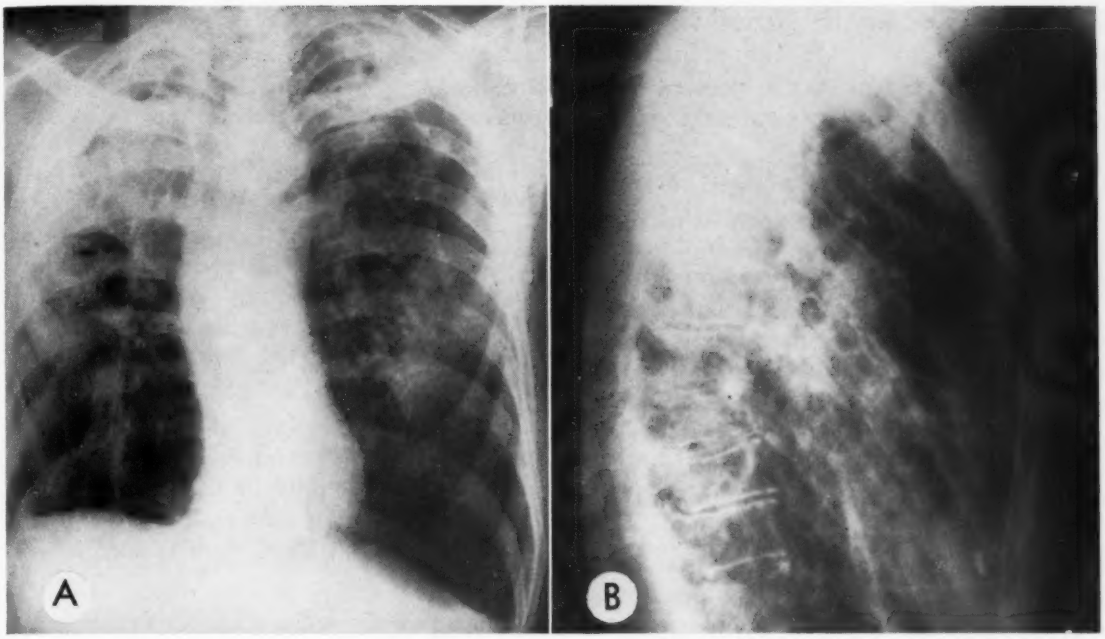

Fig. 15. Case xx. Chronic Friedländer's pneumonia. There is extensive pulmonary fibrosis and cavitation, most marked in the upper lobes, with upward shift of hili and displacement of the trachea to the right.

ever, following repeated cultures of Friedländer's bacilli from the sputum, the diagnosis was changed from tuberculosis to chronic Friedländer's pneumonia and treatment changed to streptomycin and chloramphenicol.

During the hospital course there were no changes in the roentgenographic appearances of the chest. The patient's condition gradually deteriorated despite therapy and he died four months after admission. Permission for autopsy was not granted.

Comment. This case of presumed chronic Friedländer's pneumonia presented a roentgenographic appearance indistinguishable from that of pulmonary tuberculosis. This was the clinical diagnosis until bacteriologic studies failed to support it, and demonstrated Friedländer's bacilli on repeated occasions. Nowadays, it is doubtful if a case of acute Friedländer's pneumonia correctly diagnosed and promptly treated with the correct antibiotics would proceed to such a marked degree of chronic disease. In this series, the cases of acute pneumonia, which have been followed after recovery, have shown degrees of fibrosis varying with the amount of lung initially involved. However, even the severe cases of acute pneumonia, that recovered and passed into the chronic phase, did not show such striking fibrosis as Case xx, the difference probably being due to the influence of antibiotic drug therapy.

DISCUSSION

Previous writers[12,16] have drawn up classifications of Friedländer's pneumonia based on its various roentgen appearances. While the lobar and lobular or bronchopneumonic types were encountered in the present series, it seemed that the roentgen picture when first seen was merely due to a combination of the resistance of the individual, the virulence of the organism and the length of time without treatment from the onset of the disease until roentgen examination. Many of the cases simultaneously showed a lobar consolidation in one lobe and bronchopneumonic consolidation in others. A segmental type of consolidation, not previously described, was encountered frequently. Segmental consolidations were previously suggested[7] on the basis of single frontal projections, but

roentgenograms in the lateral view were not available to clarify the point. Most frequently involved in the present series were the anterior and posterior segments of the right upper lobe.

It is commonly accepted that increased volume of the involved lobe, with bulging of the bordering fissure, is a hallmark of Friedländer's pneumonia. Accounts of the pathologic findings in pneumococcal lobar pneumonia describe the involved lobes as voluminous,[2] and roentgenographically, pneumococcal lobar pneumonia may on occasion cause bulging of fissures. Increase in lobe volume is therefore not an exclusive feature of Friedländer's pneumonia. A lobe entirely consolidated by any pneumonic process is airless, heavy and sinks in water. In the 4 cases of Friedländer's lobar pneumonia described by Olcott,[15] the involved lung weighed from two to three times as much as the opposite normal lung. Early formation of a fibrinous pleural exudate occurs in Friedländer's pneumonia. Inasmuch as the displacement of fissures is often marked, and the increase in volume described pathologically is usually slight, and since most lesions are in the upper lobe, it seems reasonable to conclude that a certain amount of fissure displacement is due to the great weight of the consolidated lobe, which is held in position peripherally by pleural adhesions but which sags inferiorly in its central portion. As noted above, all the cases in the present series showing fissure displacement and curvature convex from the lesion were in the upper lobe. Another factor which may contribute to increased lobe volume in certain instances is the presence of cavitation. Ball-valve action may increase the intracavitary pressure with a consequent increase in the size of the cavity, and hence, of the entire lobe.

On reviewing the literature on this subject one cannot fail to be impressed with the number of cases of chronic Friedländer's pneumonia which have simulated or initially been mistaken for tuberculosis. Since the two diseases can have identical roentgen appearances, it remains for the roentgenologist to be aware of this and to aid in the proper diagnosis and disposal of the case.

SUMMARY AND CONCLUSIONS

The clinical and roentgen features of 19 cases of acute and 1 case of chronic Friedländer's pneumonia are described and discussed. The pathology is reviewed.

The average acute case occurs in an elderly male, frequently an alcoholic, with a history of chronic debilitating disease. The right upper lobe is the favorite site of the consolidation, which may involve less than a segment or the entire lobe. Early abscess formation and downward bulging of the adjacent fissures frequently occur.

Early diagnosis of acute cases is imperative so that prompt administration of the correct antibiotic drugs may be instituted. Streptomycin is the drug of choice but aureomycin and chloramphenicol have been used with success.

Most cases survive the acute pneumonia and pass into the chronic stage. This is characterized by fibrosis and cavity formation, and the tendency to exacerbations of acute pneumonia.

It is of prime importance to consider the possibility of chronic Friedländer's pneumonia in all instances of pulmonary fibrosis and cavitation, particularly in the upper lobe, as such a case may be erroneously diagnosed and treated as tuberculosis.

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DISCUSSION OF THE PAPER ON FRIEDLÄNDER'S PNEUMONIA

DR. L. L. ROBBINS, Boston, Massachusetts. It is a great pleasure to hear such an excellent and complete summary of the findings in a rather uncommon yet extremely important disease. Actually, I shall have to simply emphasize some of the points of greater value in the diagnosis, as Dr. Holmes has covered the subject so thoroughly and I am sure I know nothing beyond that which he has already mentioned.

Dr. Holmes has stressed that the clinical findings run a reasonably typical course, although there may be variations. Most often the disease is found in older males, and particularly those in a debilitated state. The onset is rather characteristic in at least half of the cases, in that it is sudden and severe. Typically there is a thick, viscid sputum which may occasionally be brown or cherry red.

Dr. Holmes has indicated that certain points about the roentgenologic appearance may cause obfuscation. First, the disease occurs most often in the upper lobes, and therefore it is confused with tuberculosis. Then cavities are prone to develop, and in consequence there may be serious consideration of tuberculous abscess or, in occasional instances, necrotic tumor.

The bulging appearance of the fissures when seen in its typical form is a very significant roentgenologic finding, and can apply to any portion of any fissure. I believe it is found only in certain specific conditions. It should not be confused with the normal, slight curve which is produced by the various fissures. Furthermore, I think it is important to recognize that this is a true bulging in most cases, and not particularly a sagging of the fissure; that is, if we use it in various positions in various fissures.

A marked bulging of the fissure associated with consolidation or collapse usually means that the disease process is the result of (1) tumor, (2) abscess, (3) Friedländer's pneumonia or (4) plague pneumonia. Personally, I have not seen true bulging of the fissures in conditions other than these.

If the radiologist is aware of both the clinical and roentgenographic findings which have been summed up in this paper, he can usually suggest the correct diagnosis, and this can often be established very rapidly by means of bacteriologic studies.

I have discussed this paper and the condition it describes with some of the clinicians at home, and they have emphasized the importance of early, rapid diagnosis in these cases. In fact, they feel that Friedländer's pneumonia is verging on the emergency group of diseases of the lung. This is true, because if the disease process is allowed to go on for merely a matter of days, permanent injury to the lung may result. Therefore, the sooner the diagnosis can be made without delay entailed in bronchoscopy and other studies not strictly pertinent to the diagnosis, the more chance of recovery and the less chance of permanent injury.

Certainly streptomycin or one of the other broad spectrum antibiotics should be used immediately and thoroughly if the chronic form of the disease is to be avoided.

I should like to congratulate Dr. Holmes on his very excellent presentation.

DR. CARLETON B. PEIRCE, Montreal, Canada. I appreciate very much the opportunity to add to this discussion. Dr. Holmes has brought out very well the rather serious character of this infection, which Dr. Robbins has emphasized.

Also, Dr. Robbins brought up the matter of the emergency character of the disease. Our experience has been that for the most part, although fatality in this disease is early, a number of chronic cases will be seen. Associated with the low reaction of the blood in the fatal cases, the patient often will present abdominal symptoms primarily, and an acute respiratory disease, almost in the form of complete respiratory collapse, with the result that either his physicians are confused as to whether or not it is an abdominal situation, or they are at a loss to cope with the respiratory problem.

In our experience also it has been common that the organism is in the nature of a saprophyte in the upper respiratory tract, the paranasal sinsues. This is more usual of course in the chronic cases, but often affords a clue to the etiology if one has opportunity to do a bacteriological differentiation.

Dr. Robbins and Dr. Holmes have emphasized the necessity for early administration of suitable antibiotics. Although it is wise to administer a rather broad-spectrum antibiotic at first, before you have a chance to do a sensitivity differential, certainly the bacteriologic or antibacterial titer of the various antibiotic materials should be determined as early as possible.

The contralaterality of dispersal of the infection is also very common in our experience, together with cavitation.

If Dr. Holmes has the information, I would like very much to know how frequently abdominal symptoms appeared in his series, and how often he noted concurrent or pre-existing saprophytic infection of the paranasal sinuses.

DR. BENJAMIN FELSON, Cincinnati, Ohio. We have reported an additional sign in Friedländer's pneumonia, and I would like to ask if the essayist has had any experience with it.

The margins of the pneumonic infiltrate in the frontal view, as well as in the lateral view, may be quite sharp, even when the pneumonia does not abut a fissure. For example, involvement in the left upper lobe, exclusive of the lingula, may present such a sharp lower border that it resembles a fissural margin.

I wonder if Dr. Holmes has encountered such cases.

DR. HOLMES (closing). In answer to some of the comments by Dr. Robbins, the problem of bulging fissures concerned me right from the beginning. The pathologists who have done autopsies on these cases do not seem to mention any striking increase in lobe volume, and on no occasion was I able to find any description of any bulged fissure that would at all compare with what was seen in the films.

Sometimes it is difficult to get a good roentgenologic-pathologic correlation because some of these patients die rapidly, often before there has been any opportunity for roentgen examination. I think we must agree that whatever the cause is, the bulging fissure certainly is one of the hallmarks of Friedländer's pneumonia.

As far as its being an emergency disease is concerned, some of our early cases died within a matter of hours after admission. Even with the new antibiotics we will still continue to have deaths, because these patients usually come from the level of society where they do not give the doctors much chance to treat them.

In connection with Dr. Peirce's question about patients being admitted with abdominal signs and symptoms, I cannot recall any who were admitted specifically with abdominal complaints. However, it does bring up the important point that the radiologist should be alert, because many of these patients are diabetics and alcoholics. Some of our cases were

admitted in diabetic coma, and no history could be obtained. It was not until the films were taken that any suspicion of a pulmonary lesion existed. The same applies to patients who are admitted in advanced stages of alcoholism and cannot give any coherent history.

Regarding the presence of saprophytic organisms, it is certainly true that these bacteria are present in the nasopharynx and the upper respiratory tract of a considerable number of healthy persons, and in an even higher percentage of people who do have chronic infections either in the lungs, nasopharynx or paranasal sinuses. These are the people who I believe are most likely to develop an acute pneumonia if their resistance is lowered any further.

In answer to Dr. Felson's question about the sharpness of the margins of the lesions, I did not mention this point today because I was not particularly impressed with it. I was aware it had been described. I believe that the sharp or relatively sharp border certainly is never as sharp as the fissure border, and I think that it probably represents the segmental outline of the consolidated portion of the lung.

PULMONARY TUBEROUS SCLEROSIS

REPORT OF A CASE

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IN A recent exhaustive and scholarly paper, Dawson reviewed the subject of pulmonary involvement in cases of tuberous sclerosis and brought to light the fact that only 9 bona fide cases of pulmonary tuberous sclerosis had been reported. Dawson added 4 cases of his own. By surveying the records of many hospitals in and around London, Dawson was able to collect 64 cases of tuberous sclerosis associated with mental deficiency and with adequate information about the lungs. In only one of these patients were the lungs affected. Dawson's estimate that tuberous sclerosis associated with mental deficiency occurs once in every 300,000 persons in the general population indicates how rare the disease is. And the additional association of pulmonary involvement is seen to be markedly less common. Of even more interest is the finding that although adenoma sebaceum without mental deficiency occurs with about the same rarity as it does with mental deficiency, pulmonary tuberous sclerosis usually is observed among persons who are not mentally defective. "They usually come to light because of pulmonary symptoms in patients who are then found to have other stigmata of tuberous sclerosis."[1]

In the case that we are reporting, the condition presented as a pulmonary problem in a woman of normal intellect. Although we do not have pathologic confirmation of our contention, we consider that the association of adenoma sebaceum and subungual fibromas in the presence of pulmonary changes for which no other explanation could be found justifies our presumptive diagnosis of pulmonary tuberous sclerosis. Although mental deficiency is usually regarded as an integral part of the disease, tuberous sclerosis, it should be recognized that this is not necessarily so. Furthermore, as Dawson has stated, the presence of adenoma sebaceum alone is proof of tuberous sclerosis, and subungual fibromas do not occur in any other condition.

For details as to the pathogenesis, clinical and pathologic picture of pulmonary tuberous sclerosis, the reader is referred to Dawson's paper. Salient findings are: the development of progressive dyspnea without cough in a patient, usually a woman between twenty and forty years of age; episodes of spontaneous pneumothorax in about a third of reported cases; roentgenographic evidence of widespread coarse mottled lung markings, often suggesting multiple cystic disease; other stigmas of tuberous sclerosis, usually without mental deficiency. Death usually occurs within a decade after symptoms have started.

REPORT OF A CASE

A forty-eight-year-old public school nurse reported to the Mayo Clinic in 1952 with chief complaints of dyspnea and fatigue. Dyspnea had been present since the age of forty-three

* The Mayo Foundation, Rochester, Minnesota, is a part of the Graduate School of the University of Minnesota.

Fig. 1. Note evidence of adenoma sebaceum.

years. She also had noted slight acrocyanosis on exertion. Main points given in the history were as follows: influenza and pleurisy with effusion in 1928; hysterectomy for uterine bleeding in 1947; an episode of pneumonia in 1951 and again in 1952. She denied having any cough or pain or having lost weight and she did not give a history of convulsions. Examination of the digits did not show evidence of clubbing, but did show typical periungual and subungual fibromas—these had been present for thirty years. The skin of the cheeks and nose revealed typical adenoma sebaceum, which the patient stated had been present since the age of three years (Fig. 1). Because of a possible mass in the right flank, an excretory urogram was made. The urologic summary stated that the left kidney was normal, but that the right kidney showed ectopia of mild degree. Examination of blood revealed a value for hemoglobin of 11.9 gm. per 100 cc.; the hematocrit reading showed the volume of erythrocytes to be 67 per cent and this was thought to be secondary to her pulmonary condition. Oxygen saturation as

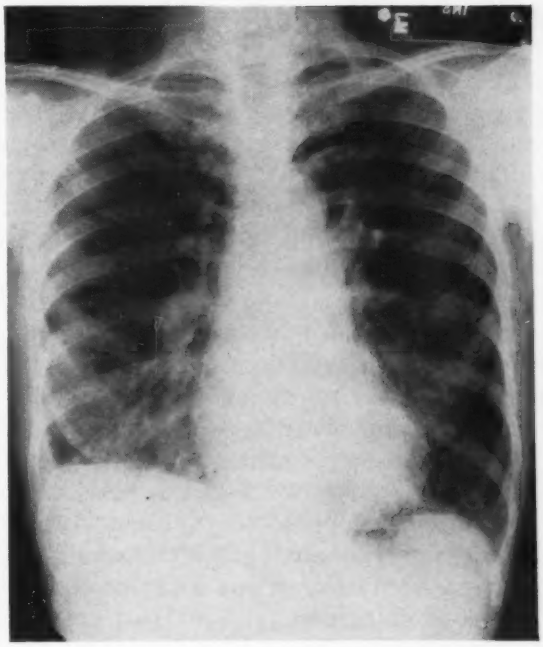

Fig. 2. Posteroanterior roentgenogram of the thorax showing bilateral, coarsely mottled and reticulated pathologic process; some areas give the appearance of cystic disease.

measured by the ear oximeter revealed an oxygen saturation at rest of 85 per cent, which decreased to 74 per cent after the patient exercised for four minutes on a treadmill, but increased to 100 per cent after she breathed oxygen for ten minutes.

Culture of sputum and gastric content did not reveal evidence of fungi or of Mycobacterium tuberculosis. Results of a second strength tuberculin test were positive.

The roentgenogram of the thorax showed evidence of a bilateral, coarsely mottled and reticulated pathologic process, which in some regions appeared like cystic disease (Fig. 2).

COMMENT

The reasons for considering this case as one of pulmonary tuberous sclerosis have been presented. The clinical and roentgenologic findings in most respects show a striking resemblance to those in cases of pulmonary tuberous sclerosis previously described in the literature. Although a history suggestive of spontaneous pneumothorax had not been obtained, this condition is not by any means an invariable accompani-

ment of the disease. Of considerable interest is the absence of cough or evidence of pulmonary inflammation in spite of what appears on the roentgenogram to be a widespread and chronic pathologic process.

The cases reported in the literature which included pathologic studies of the lungs, revealed, on gross examination, many small cysts in a relatively solid lung. The cysts were in various stages of development, varying from pin-point size to about 1 cm. in diameter. Many were situated subpleurally. Usually they were filled with clear fluid, but some have been shown to communicate with the bronchial tree. Rupture of such cysts presumably accounts for spontaneous pneumothorax. Microscopic examination of the lining of the cysts showed that occasionally it was composed of cylindrical bronchial epithelium or alveolar-like epithelium, but as a rule there was no epithelial lining at all.[3]

The walls of the cysts consisted largely of connective tissue containing numerous blood vessels. But the most interesting component was smooth muscle tissue, with "the unmistakable character of tumorous tissue," and a cellular arrangement similar to that in myomas. "The lungs thus present, apart from the general cystic transformation, the aspect of a diffuse myomatosis, which must be considered as very closely related to genuine tumor formation."[3]

Since the publication of Dawson's paper, Silverstein and Mitchell[2] have reported another case of pulmonary tuberous sclerosis. Their patient was a twenty-three-year-old female who presented a predominantly pulmonary problem. Skin lesions of tuberous sclerosis were present. A roentgenogram of her skull revealed intracranial calcifications in spite of the fact that, clinically, a neuropsychiatric component did not exist. The long bones and kidneys showed roentgenologic evidence of tuberous sclerosis. The roentgenogram of the thorax included in the report appears to be almost identical to that in our case. This patient died after several episodes of spontaneous pneumothorax. Necropsy was not obtained.

SUMMARY

To date (1955), reports of 14 cases of pulmonary tuberous sclerosis have appeared in the literature. We have added another case which, although lacking pathologic confirmation, was presumptively diagnosed as pulmonary tuberous sclerosis because of the association of adenoma sebaceum and subungual fibrosis in the presence of pulmonary changes for which no other explanation could be found.

Attention is drawn to the fact that pulmonary tuberous sclerosis usually occurs among adults who are not mentally deficient, but who usually do have other characteristic findings of the disease such as adenoma sebaceum, periungual and subungual fibromas, renal tumors, intracerebral calcification and regions of sclerosis in the long bones.

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ROENTGEN ASPECTS OF INTRATHORACIC BLASTOMYCOSIS*

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DURING the past fourteen years blastomycosis has been encountered in 18 patients at the Cincinnati General Hospital. We have had the opportunity of reviewing the chest roentgenograms of 17 of these and, in addition, have examined the films of 8 patients from other Cincinnati institutions. A number of the patients presented striking intrathoracic abnormalities attributable to this fungus. The present study was undertaken to ascertain the incidence of the various roentgen patterns encountered and to determine if any of these patterns might be diagnostic of the disease.

Most of the cases in the present report were included in a previous communication on blastomycosis by Schwarz and Baum.[12] These authors did not, however, deal primarily with the roentgen aspects of the disease.

GENERAL FEATURES

North American blastomycosis is a chronic infectious disease caused by Blastomyces dermatitidis and is characterized by suppurating granulomatous lesions in the skin and internal organs. No authentic case has been reported originating outside North America. So-called European blastomycosis is, for the most part, torulosis, and the South American form is caused by Blastomyces brasiliensis. Blastomycosis is not particularly rare in the United States. The majority of the cases have been reported from the mid-west, North Carolina, and Louisiana.[1,13] It is probably much more common that published reports would indicate, since the incidence seems to parallel medical interest in the disease.[10] There is no racial predilection and males over forty are said to be most frequently affected.

The mode of entry of the fungus into the body is now believed to be via the respiratory passages, although the organism may rarely gain entrance through the skin, as in the accidental inoculation of laboratory workers.[13,14] Blastomycosis may involve practically any organ in the body, so that the signs and symptoms of the disease are quite variable. Two clinical forms of the disease are generally designated, the cutaneous and the systemic.[4,9,11] However, since most of the cases manifesting the cutaneous form are ultimately shown to have visceral lesions, and conversely, the skin is affected in most instances of the systemic form, there may well be no justification for their separation as clinical entities. Indeed, when visceral (*e.g.*, pulmonary) lesions are demonstrated in a patient with proved cutaneous blastomycosis, experience indicates that one may reasonably assume the presence of systemic blastomycosis rather than some coincidental disease.

The individual skin lesion originates as a pustule, but soon becomes centrally necrotic. It later appears as a painless, draining, crusted elevation.

Pulmonary involvement is quite common. It may be completely asymptomatic or give rise to fever, malaise, weight loss, chest pain, cough, dyspnea, and hemoptysis. The sputum is usually gray or brown and often viscid. Polymorphonuclear leukocytosis and increased sedimentation rate may occur.

A positive blastomycin skin test is not uncommon in the disease. Since it is most unusual in the normal healthy population, a positive skin test may be quite helpful in suggesting the diagnosis. The complement fixation test is often negative, but when positive in high titer it indicates ac-

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tive disease. Patients surviving a blastomycotic infection usually have shown a positive skin test and a negative complement fixation test.[6]

The diagnosis of blastomycosis is established in the laboratory by the demonstration of the organism. Blastomyces dermatitidis may be readily visualized in biopsy tissue and has been isolated culturally from skin lesions, sputum, endobronchial smear and biopsy,[17] urine, and prostatic secretion. Positive blood cultures are extremely rare. The fungus grows as a mold on artificial culture media at room temperature. It produces budding organisms at 37 degrees C. and mycelia at 20 degrees C. In tissue sections it appears as a double refractile oval or round body, 8 to 24 micra in diameter, with granular content, and single buds.

The lungs, when involved, reveal a variety of lesions. These may be characterized by disseminated miliary granulomas, by single or multiple abscesses or nodular areas of consolidation, or by parenchymal scarring and fibrosis. The pleura is often affected, but significant amounts of pleural effusion are not common. Lymphatic spread to the hilar and mediastinal lymph nodes may occur. Calcification may be present within areas of scarring in the parenchyma and in affected lymph nodes. This, however, is an uncommon occurrence.

The gross appearance of the pulmonary lesions may closely mimic that of tuberculosis. Microscopically also this resemblance is occasionally striking. Tubercles indistinguishable from those of tuberculosis may be found. In exudative lesions a more diffuse infiltration containing polymorphonuclear leukocytes is seen. Blastomyces are usually present within the lesions and may be abundant in the tenacious sputum in the bronchial tree. Spread of the disease to distant organs, especially the skin, bones, kidneys, and brain, occurs by way of the blood stream.

In the past treatment has been unsatisfactory. Iodides, vaccines (blastomycin), aureomycin, and radiation therapy have been utilized without significant long term benefits. More recently stilbamidine and its derivatives have been employed and appear to be much more efficacious in controlling the disease.[1,16] Surgical excision of localized skin lesion has proved beneficial.[8] In individual cases presenting a single well-circumscribed pulmonary lesion, surgical resection has been performed, sometimes with excellent results.[2,7,9,15] In the past the mortality rate from blastomycosis was said to be approximately 90 per cent, death usually occurring within three to five years. It now appears that this rate will be considerably lowered by the newer methods of therapy.[14]

Roentgen Findings. A variety of roentgen findings has been reported in pulmonary blastomycosis. As might be expected, these have paralleled the gross pathologic forms described above. Diffuse miliary lesions, homogeneous consolidation, solitary or multiple nodular densities and abscesses of variable size, and fibrotic lesions have all been recorded. Pleural involvement and lymph node enlargement have also been noted.[5]

PRESENT STUDY

The initial chest roentgenogram in each of the 25 cases in the present series was reviewed and the various roentgen patterns were tabulated. In addition, the course of the disease as observed roentgenographically was studied in the 17 cases in which serial films were available.

Table 1 shows the incidence of the different roentgen patterns seen on the admission film. There were only 5 cases in which no abnormality could be detected. The remaining 20 cases revealed the following changes:

(1) Seven cases showed disseminated miliary nodulation throughout both lung fields (Fig. 1). In 3 of the 7 there were prominent areas of confluence of the lesions (Fig. 2).

(2) In 7 cases there were irregular areas of ill-defined pulmonary density, the appearance being indistinguishable from that so often encountered in chronic reinfection

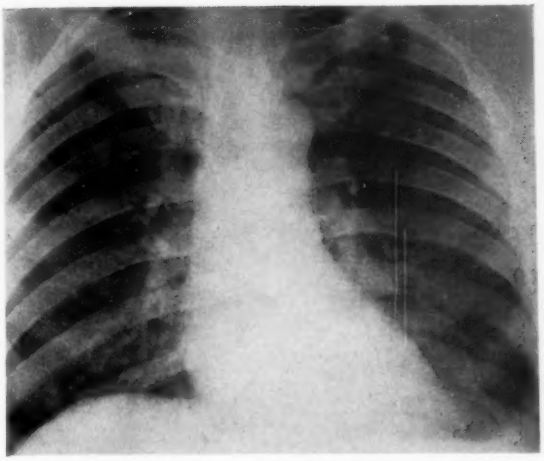

FIG. 1. (J.B.) Miliary nodulation disseminated throughout both lungs. This type of lesion was seen in 7 cases.

tuberculosis (Fig. 3). Because of the strand-like extensions often present at the margins of these lesions and the signs of contraction, this pattern was classified as fibrotic, although we appreciate the fact that exudate without fibrosis can sometimes produce this type of shadow. In each of the 7 cases there was involvement of the pulmonary apex, although in only 2 was the infiltrate confined to this region. Both lungs were affected in 5 instances. In 4 of the 7 cases the pulmonary involvement was quite extensive, although not generalized (Fig. 4). In only 1 of the 7 was cavitation seen. A diagnosis of pulmonary tuberculosis was suggested by the roentgenologist in nearly every instance.

(3) Homogeneous pulmonary consolidation, apparently segmental or subsegmental in distribution was revealed in 5 cases (Fig. 5). In each of these the lesion was solitary. One of the cases showed, in addition, a mild degree of segmental collapse.

TABLE I

PULMONARY ROENTGEN PATTERNS IN 25 CASES OF BLASTOMYCOSIS

Normal	5
Diffuse miliary nodulation	7
"Fibrotic"	7
Homogeneous consolidation	5
Tumor	1

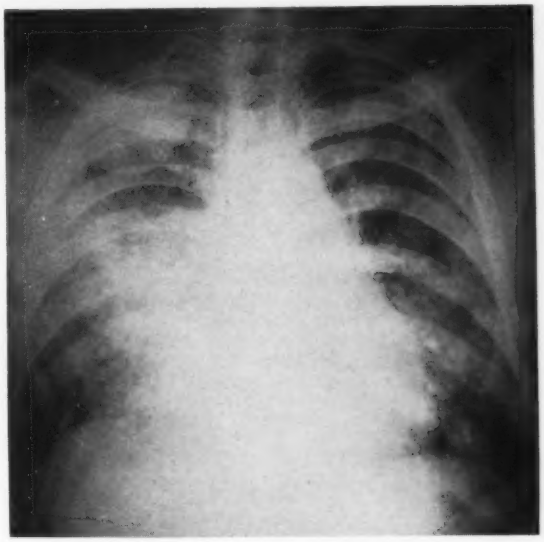

FIG. 2. (S.A.) Diffuse miliary nodulation with areas of confluence. There is destruction of the right second rib associated with a very sharply circumscribed soft tissue mass protruding into the thorax. At autopsy this was found to be an extrapleural abscess.

(4) One case presented a solitary pulmonary lesion with rather well-defined lobulated margins. It was originally thought to represent a neoplasm.

Lymph node enlargement was detected in only 3 of the cases and in none of these

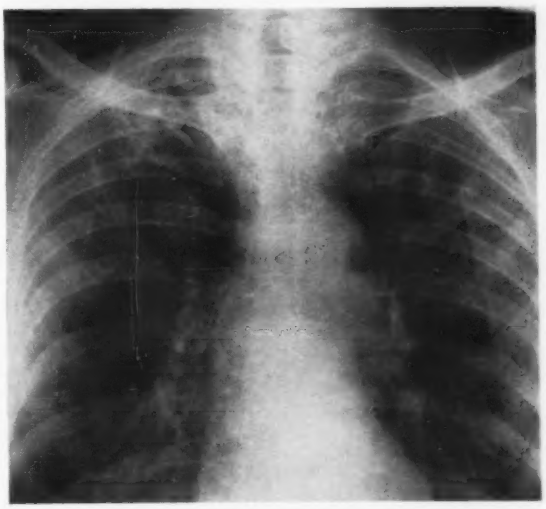

FIG 3. (S.B.) Irregular, ill-defined density in right apex, simulating that often seen in chronic reinfection tuberculosis. This type of lesion was seen in 7 cases.

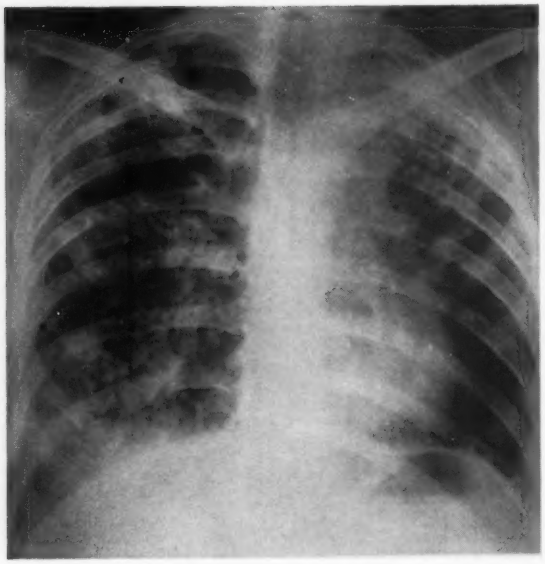

Fig. 4. (R.S.) Extensive fibrotic pulmonary lesions. Small cavities are seen in both apices. This patient also shows localized pleural involvement over the left apex and right base.

Fig. 6. (E.M.) Right bronchogram, lateral view. Localized pleural involvement anteriorly, overlying the involved middle lobe.

was it striking. In each instance the adenopathy appeared to be confined to the hilar nodes. It was bilateral in 1 case and unilateral in 2. In several other cases a small amount of calcium was visible in the lungs and lymph node areas but this was regarded as incidental since it was not located in proximity to the pulmonary infiltrate.

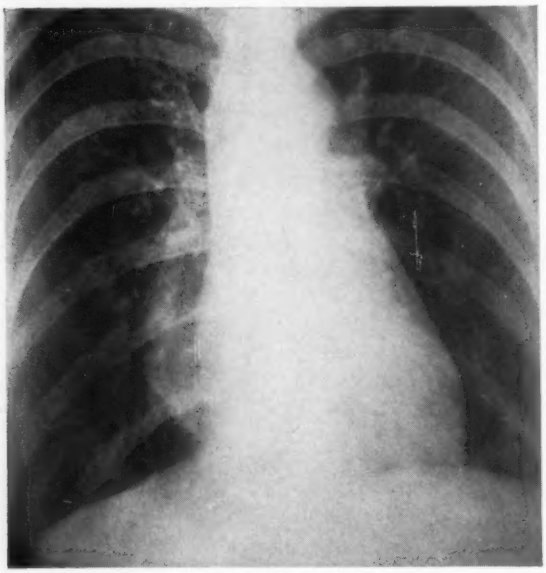

Fig. 5. (E.M.) Homogeneous pulmonary consolidation in the medial segment of the right middle lobe. This type of lesion was seen in 5 cases.

Pleural involvement was commonly encountered. It was seen in 10 cases, in each of which the pleura appeared irregularly thickened in one or more localized areas (Fig. 4 and 6). The presence or absence of small amounts of encapsulated fluid within the areas of pleural thickening could not be determined, but evidence of free pleural effusion was lacking. The pleural involvement was often situated close to one of the localized pulmonary infiltrates. In 2 of the 5 cases with normal admission films unilateral obliteration of a costophrenic sinus was noted. Because this is a common incidental finding, these cases were not included among the 10 with pleural disease.

Follow-up roentgenograms were avail-

able in 17 of the 25 cases. In 8 of these the period of observation was less than one year. In 7 of the 8 the roentgenograms showed progression, while in only 1 was improvement noted. Of the 9 cases followed for a period of from one to five years, 2 showed regression, 4 progression, and 3 remained stationary. Since many different therapeutic agents were used in these patients the response to treatment could not be evaluated.

In 2 cases presenting a diffuse miliary pattern the lesions appeared to regress roentgenologically despite absence of clinical improvement. In one of these, later films revealed a distinct increase in the size and number of the lesions. In the other, the patient died a short time after the roentgen improvement was noted, and countless miliary lesions were found at autopsy.

In 4 instances the pattern noted on the admission roentgenogram was subsequently observed to change. In a patient with diffuse miliary nodulation, a superimposed homogeneous consolidation appeared in the lingula several months later. In a patient with unilateral fibrotic densities, miliary spread throughout both lungs occurred. A patient with far-advanced bilateral fibrotic involvement developed, in addition, persistent collapse of the left upper lobe. The fourth patient, who had a lobulated mass in the left lower lobe on admission, later revealed an extensive mottled infiltrate in the left lung which obscured the original lesion.

In an additional case the roentgen course was of particular interest. The admission roentgenogram revealed a consolidation in the anterior segment of the right upper lobe adjacent to the minor fissure. On subsequent films the lesion appeared to have extended directly through the minor fissure into the adjacent portion of the right middle lobe. This was confirmed in the specimen removed at operation.

In 6 cases bone lesions were demonstrated roentgenographically. These were all purely osteolytic in character, suggesting destruction due to neoplasm. They were associated, however, with a strand-like network of irregular markings in the overlying soft tissues, a change consistent with inflammatory swelling. Various bones were affected, and the lesions were multiple in 2 of the 6 cases. Rib destruction was apparent on the chest roentgenograms in 2 cases. One of these was associated with a soft tissue mass which protruded into the thorax (Fig. 2). At autopsy the mass was found to represent an extrapleural abscess.

Autopsy material was available in 7 cases and surgical specimens of the lung in 2 additional instances. Review of the pathologic reports revealed a close correlation between the gross pathologic descriptions and the roentgen findings in each instance. All the autopsied cases revealed extensive pulmonary involvement. In 6 cases diffuse miliary involvement was found, and in the seventh there were irregular patches of chronic lobular pneumonia and fibrosis with rather widespread distribution. None of the cases showed cavitation. Lymph node involvement was mentioned in only 2 cases, and in both was moderate in degree.

Fibrotic pleural thickening was found in 6 of the 7 autopsies and in both of the operated cases. In addition, thin clear pleural fluid was found in considerable amounts at autopsy in 2 cases, but was thought to have developed during the agonal period. Adhesions obliterated all or most of both pleural cavities in 4 of the 7 autopsied cases. Since pleural obliteration is also a very common finding in routine autopsies, its relationship to the pulmonary blastomycosis could not be established in this small series.

In 2 autopsies involvement of the extrapleural tissues was specifically mentioned. In one, previously discussed, there was an abscess associated with a destructive rib lesion. In the other, multiple plaque-like lesions extending from the outer surface of the parietal pleura to the periosteum of the adjacent ribs were described. In each case the pleural space underlying the extrapleural lesion was obliterated. As noted earlier, extension of the blastomycotic

process through the minor fissure occurred in 1 of the operated cases.

DISCUSSION

From the foregoing it is apparent that there are no specific diagnostic roentgen signs of pulmonary blastomycosis. The diffuse miliary pattern encountered in this disease is indistinguishable from that found in many other conditions.[3] Similarly, the "fibrotic" and "consolidation" patterns appear identical to those of tuberculosis, neoplasm, and other pulmonary conditions. Nor is the course of the disease, as followed roentgenographically, of any particular help in differential diagnosis.

However, a lead to the correct diagnosis may occasionally be afforded by the demonstration of disproportionate pleural involvement, or of rib destruction. While pleural extension occurs with many other chronic pulmonary diseases, in blastomycosis this seems to be a more prominent feature. The pleural lesion is seldom associated with evidence of effusion, and presents as a fairly broad but relatively localized irregular thickening along the inner border of the thoracic wall.

The involvement of the extrapleural space which occasionally occurs in blastomycosis would be a helpful sign were it not that its roentgen differentiation from intrapleural disease is often difficult or impossible. An extrapleural lesion can sometimes be suspected by its broad base on the periphery of the internal thoracic wall and by its extremely sharp convex inner border (Fig. 2). The demonstration of periostitis in an overlying rib is important confirmatory evidence. Extrapleural involvement is more commonly found in actinomycosis.

Rarely in blastomycosis a pulmonary lesion may extend through an interlobar fissure. In the one example of this type of extension in the present series, the correct diagnosis was suggested from the roentgenogram.

Blastomycosis should be given consideration when a destructive bone lesion is found in conjunction with any of the pulmonary or pleural manifestations described above, notwithstanding the fact that similar findings are sometimes seen in metastatic neoplasm, tuberculosis, and other diseases.

The dermatologic manifestations are the most important clue to the diagnosis of blastomycosis. The presence of granulomatous skin lesions associated with any indolent intrathoracic lesion should suggest the possibility of blastomycosis. However, in some cases skin involvement is inconspicuous or absent, and in these the diagnosis is much less frequently considered. In any chronic undiagnosed pulmonary condition, the possibility of blastomycosis should be entertained, and a careful search for the fungus made, as the disease is not uncommon and early diagnosis now holds forth a reasonable hope of cure.

SUMMARY

1. Significant intrathoracic roentgen abnormalities were encountered in 80 per cent of a series of 25 cases of North American blastomycosis.

2. Relatively few different pulmonary patterns were encountered, the commonest of these being diffuse miliary involvement, fibrotic lesions indistinguishable from those of tuberculosis, and homogeneous consolidation.

3. Cavitation and lymphadenopathy were quite infrequent, but pleural involvement was common and bone involvement not rare.

4. The course as indicated by serial roentgen studies of the pulmonary lesions was most commonly one of slow progression.

5. No diagnostic roentgen features were recognized in this material, although the disproportionate degree of pleural involvement, the occurrence of extrapleural extension, and the demonstration of destructive bone lesions might provide clues to the diagnosis.

6. The presence of a chronic undiagnosed pulmonary process, especially if associated with granulomatous skin lesions, is an in-

dication for a thorough search for Blastomyces dermatitidis.

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SECONDARY VASCULAR CHANGES IN THE LUNGS*

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THE more servere cases of mitral stenosis and/or insufficiency, chronic cor pulmonale and certain congenital cardiac lesions have in common pulmonary hypertension and right ventricular hypertrophy. Cardiac catheterization has revealed, also, that pulmonary resistance, a physiologic term expressing the relation of pulmonary artery pressure to pulmonary flow, is increased. The nature of this resistance is of considerable interest. We shall consider here to what extent it is due to structural vascular changes in the lungs. The subject is important to the radiologist in his consideration of the vascular patterns in the lungs and the cardiac configuration.

DYNAMICS OF THE PULMONARY CIRCULATION

The pulmonary circulation is largely regulated by the output of the right ventricle and the resistance in the left auricle, and is modified greatly by the mechanical distensibility of the small pulmonary vessels. These vessels are thought to respond also by reflex action and by direct action of the respiratory gases. There are also modifying anastomoses between bronchial and pulmonary vessels, the precise physiologic importance of which is still under investigation, but there is little doubt that they constitute a sizable potential or actual shunt in lung disease.

The pathophysiologic changes in the pulmonary circulation vary considerably depending on the severity of the disease and represent the resultant of many complex factors operating somewhat differently in different individuals. Average figures for various diseases have little meaning. However, in order to give a rough idea of the size and direction of the changes, we prepared a simple chart grossly averaging published data (Table 1).

In the normal individual, when the cardiac output is doubled by exercise, there is no increase in pulmonary artery pressure; there may be a slight decrease. This is consistent with a ready marked distensibility of the pulmonary vessels. Anoxia produced by breathing 10 per cent oxygen results in a distinct increase in pressure, but no change in cardiac output, so that the pulmonary resistance is increased. This is thought to result from vasoconstriction. In mitral disease, cardiac output is lower than normal but the pressure is considerably increased. This means a marked increase in total pulmonary resistance. Since the pulmonary capillary pressure (measured as the pulmonary artery "Wedge" pressure) also is increased, part of the increased resistance is due to elevated left auricular pressure but calculation indicates that there is also increased arteriolar resistance. With exercise, there is a further increased resistance in both factors. In severe pulmonary disease, both pulmonary artery pressure and flow are increased. When cardiac failure occurs, it is a high output failure. Calculation indicates that there is a slight increase in total pulmonary resistance, apparently largely arteriolar. With exercise, resistance is further increased, suggesting that the pulmonary vessels do not have as ready a distensibility as the normal when exposed to increased flow.

Swan, *et al.*[12] list the factors controlling pulmonary artery pressure as follows:

1. Increase in the resistance to flow beyond the pulmonary capillaries. This occurs in mitral disease, congestive failure and constrictive pericarditis.
2. Increased pulmonary flow with un-

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Table I

		Cardiac Index (Output)	Pulmonary Artery		Pressure Mean	"Wedge" Pressure
			Systolic	Diastolic		
Normal	rest	3.1	20	5	15	<12
	anoxia	3.0	35	15	25	
	exercise	5.4	15	5	10	
Mitral stenosis	rest	2.3	65	35	45	25
	exercise	2.5	100	50	70	35
Mitral insufficiency	rest	1.9			20	60
	exercise	2.0			30	55
Emphysema	mild	3.3	25	10	15	
	severe	3.6	40	15	25	
	exercise	5.7			35	
	in failure	4.6	70	35	50	
Alveolar capillary block	rest	3.9	25	10	20	
	exercise	5.6	40	20	30	

changed or lowered resistance as occurs in normal individuals with exercise or in mild emphysema.

3. Increased velocity of flow into the pulmonary system. This occurs when blood is injected from a high into a low pressure system as in ventricular septal defect.
4. Greater obstruction in small pulmonary vessels.
5. Degenerative pulmonary vascular disease including intimal hypertrophy and degeneration, atherosclerosis and arteriosclerosis, occlusive and thrombotic lesions and arteritis.
6. Reflex vasospasm of muscular pulmonary vessels.
7. Persistence of a primitive type of pulmonary vessels. This might be the mechanism in certain congenital lesions in which, as the result of markedly increased flow with hypertension, the lungs would otherwise be flooded and vascular damage ensue.

Another likely factor is the bronchial artery-pulmonary artery anastomoses. These dilated channels have been demonstrated quite clearly both in this country[9] and in England[10] by injection techniques and the study of the resultant casts of the pulmonary circulation.

The effect might be:

1. Little interchange, due to constriction of the muscular connecting vessel.
2. Flow from bronchial to pulmonary artery. This would explain (a) Oxygenated blood distal to a ligated pulmonary artery. (b) Lack of necrosis following pulmonary embolus. (c) The source of oxygenated blood in the fetal lung. (d) Source of pulmonary blood in pulmonic atresia.
3. Diversion of blood from diseased segments into the pulmonary arteries of uninvolved segments. In atelectasis, for example, the smaller pulmonary artery radicles are obstructed.
4. Diversion of blood from pulmonary arteries to bronchial arteries. This requires the assumption that pressures in the two systems at the point of anastomosis are of the same order, which is contrary to the usual thought. However, the assumption is not inconsistent with the finding that the extrapulmonary portions of the bronchial arteries are not dilated, that the smaller bronchial arteries do

Fig. 1. Hypertrophic muscle in bronchial artery (Liebow). Bronchial mucosa at top, large artery in center.

not spurt when cut, and the hypertrophied bronchial artery muscle in the intima is mainly longitudinal.

Our concern at this time is particularly with the histologically demonstrable changes in the pulmonary vessels. A short time ago, one of us prepared data regarding the frequency and significance of chronic cor pulmonale in the postmortem files of the Veterans Administration Hospital, Whipple, Arizona.[13] We have reviewed this material with special reference to the pulmonary vessels for presentation now.

CHRONIC COR PULMONALE

Chronic cor pulmonale may be defined as hypertrophy of the right ventricle which results from pulmonary disease. It is generally assumed to be initiated by pulmonary hypertension, although it is conceivable that intrapulmonary shunts might result in hypertrophy and dilatation of the right ventricle, due to increased flow, but without hypertension. Cournand[4] states that blood re-circulating in the lung cannot, via the bronchial circulation, take up more than 20 cc. per liter for each 10 per cent of oxygen unsaturation, but there is some question as to whether this calculation is valid in all abnormal states.

Chronic cor pulmonale occurs commonly at ages apt to be associated with a high incidence of coronary artery disease and insufficiency. Systemic hypertension in the presence of cor pulmonale, according to some[5], may be secondary to the cor pulmonale. Hence, the presence of myocardial disease and/or concentric hypertrophy of the left ventricle does not necessarily invalidate a diagnosis of cor pulmonale when right ventricular hypertrophy is striking as compared with the left and when adequate pulmonary disease is present. In our cases, a right ventricular thickness of 5 mm. or over was regarded as evidence of right ventricular hypertrophy. (Some limitations were noted in the previous publication.[15])

Certain pathologic changes in the pulmonary vessels are within "normal" limits. Pulmonary arteriosclerosis is as common as in the systemic circulation, but usually is less severe. Brenner[1] reported that up to 97 per cent showed microscopic changes. Welch and Kinney[14] described 2 or 3 plus lesions in the small vessels of 25 per cent of normal individuals, the percentage being much higher in the older age groups. The involved vessels are dilated. Atherosclerosis is present characterized by small, irregular, yellowish patches in the intima directed along the vessel and nearest the mouths of the branches. In the microscopic vessels,

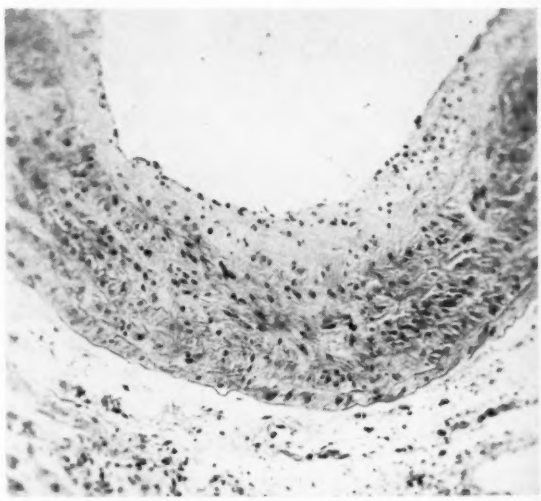

Fig. 2. Intimal fibrosis and fatty deposits in medium sized intrapulmonary artery.

the change is limited to simple intimal fibrosis.

Our material consisted of 71 cases of chronic cor pulmonale diagnosed according to the criteria given above. It included 14 cases of emphysema, in which tuberculosis also was present; it did not include patients with pulmonary tuberculosis with irregularly distributed "compensatory" emphysema. There were, in addition, 24 cases of uncomplicated emphysema and 27 cases of emphysema associated with bronchiectasis, asthma and other pulmonary disease. There was one case of bronchitis and bronchiectasis without emphysema; one of silicosis. Four cases of mitral and aortic stenosis were included in the group for study.

In some of these cases of cor pulmonale there are vascular changes which differ from those found in normal subjects. In these, the vessels are thick, due to muscular hypertrophy of the media, with subendothelial fibrosis, hyalinization and typical atheroma formation. The vessels give the appearance of being too large and too thick for the area they supply. The changes are most marked in the main intrapulmonary branches and diminish peripherally, but the latter may be marked in severe cases. The dilatation, atheroma and thickening may extend to within a centimeter of the pleural surface. In the arterioles, there is no relation between the medial changes and the degree of simple intimal fibrosis, suggesting that they are due to separate processes. The intimal fibrosis bears little relation to the disease process, while the medial changes are found associated only with severe pulmonary disease. Whether there is any reduction in the number or size of the capillaries could not be judged from the available material. The veins seem somewhat dilated, but the change is not striking. We found many examples of grossly hypertropied bronchial arteries, as described by Liebow, *et al.*,[9] but we were unable to judge their possible significance in relation to bronchial artery-pulmonary artery shunts.

Routine sections of the lungs were examined for the presence of these vascular lesions, which were graded as absent, mild, moderate or severe. The moderate and servere changes were correlated to the pulmonary disease present and the results are tabulated in Table II.

Table II

Disease	Total Cases	Distribution of Lesions: Main Pulmonary Artery	Medium Arteries	Arterioles	Number of Cases	
Tuberculosis	14	o	+	+	3	
		+	o	o	1	
		o	+	o	1	5
		o	o	o	9	
Emphysema	24	o	o	+	2	
		+	o	+	2	
		+	o	o	7	
		+	+	+	4	15
		+	+	o	2	
		o	o	o	9	
Emphysema with 27 Other Pulmonary Diseases		+	+	+	8	
		+	o	o	5	
		o	o	+	5	
		o	+	o	1	19
		o	o	o	8	
Bronchitis and Bronchiectasis	1	o	o	o	1	
Silicosis	1	o	o	o	1	

In 67 cases of pulmonary disease, therefore, there were 28 which showed mild or no vascular changes in the lungs. Twenty-four showed moderate or severe changes in the arterioles. A correlation of clinical features was attempted but none could be found. Many cases, having no vascular alterations, had just as marked right ventricular hypertrophy and clinical cor pulmonale as those with vascular changes. There is no indication that the clinical degree of em-

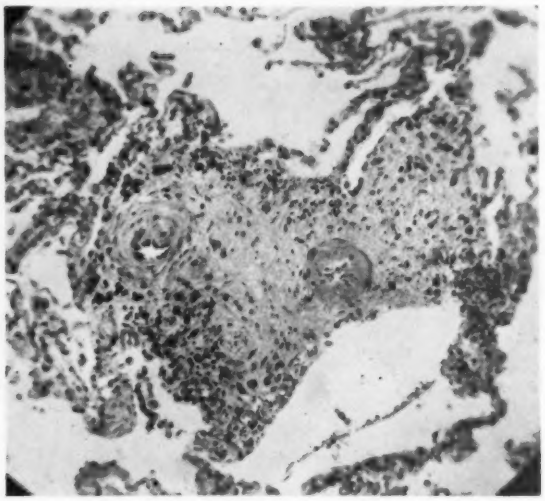

Fig. 3. Two arterioles showing severe medial thickening in a fibro-anthracotic nodule.

physema is a decisive factor in the appearance of vascular lesions. This is consistent with the usual theory that medial hypertrophy is the result of hypertension, rather than the cause of it. Parker and Weiss[11] have postulated three factors that must be present for the production of an abnormal degree of pulmonary arterial and arteriolar sclerosis: high intravascular pressure, stagnation of blood flow and precapillary edema. These are not present in emphysema. Volume flow is probably a factor, also. It is known that increase in flow may initiate arteriosclerotic changes (Welch and Kinney[14]). Cournand and his coworkers[3] have concluded from physiologic data that in emphysema, chronic anoxia with its sequelae of arterial or arteriolar constriction, polycythemia, hypervolemia and increased cardiac output perpetuate a vicious cycle of physiologic abnormalities. The element of bronchiolar spasm and obstruction are thought to be primarily responsible for the anoxia. There is no evidence from their studies or ours that the structural vascular changes contribute materially to the physiologic status, except in a secondary role.

In most of our cases, roentgenograms were available for review. (These had been made over a period of years.) In only 2 cases, in which emphysema was the dominant pulmonary disease, was the heart enlarged roentgenologically at the first observation. The remainder presented normal or small-appearing hearts. In these 2 cases, the vascular changes in the lungs were slight. Evidently, the presence of uncomplicated right ventricular hypertrophy, at least in chronic cor pulmonale, is not demonstrable roentgenologically. In 3 cases, the heart seemed to enlarge definitely and progressively over the years. A fourth showed a questionable increase in size. In 3 of these, there was considerable parenchymal infiltration. All showed marked changes in all sizes of arteries. Several cases showed cardiac enlargement during episodes of cardiac failure, but this was reversed when the failure was corrected. One must infer that cardiac enlargement shown roentgenologically is not a feature of uncomplicated emphysema, except during episodes of cardiac failure. Progressive enlargement does occur occasionally in the presence of other pulmonary disease, as well as when other heart disease is present. In these cases, severe vascular changes can be anticipated.

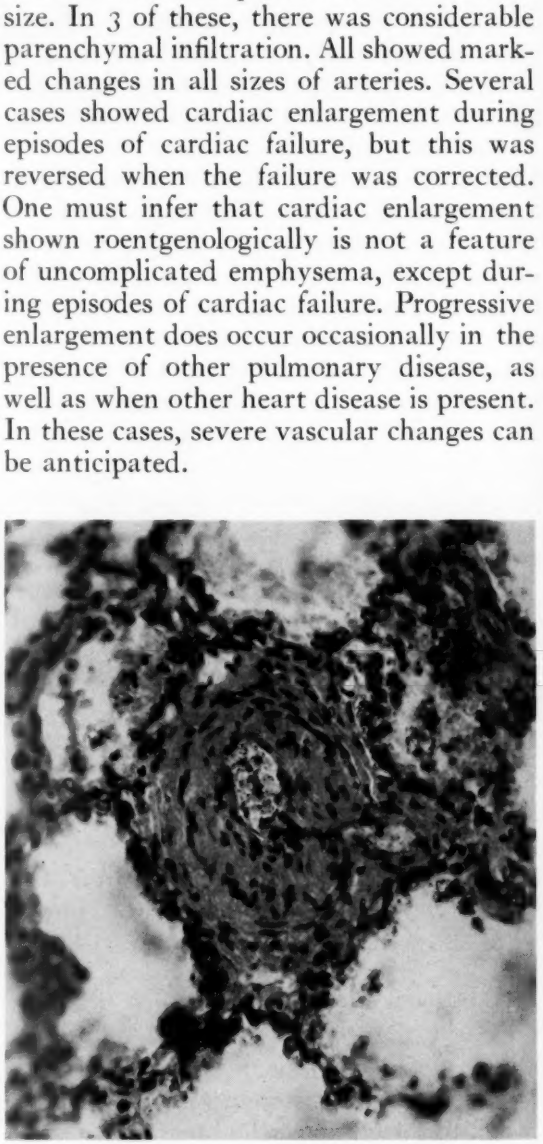

Fig. 4. Severe medial change in small artery.

Dilatation of the pulmonary artery on roentgenologic examination is a relatively uncommon finding in our group of uncomplicated emphysema; somewhat more common when there is also parenchymal disease. Progressive dilatation is sometimes observed. All of these cases were found to be associated with marked thickening of the smaller arteries.

MITRAL VALVULAR DISEASE

Our experience with the pulmonary vascular changes in mitral disease is limited. Only 4 cases of our own were available for study and of these, only 1 showed significant lesions. However, these were precisely comparable to those described in the literature[11] and to those loaned us for study by the cardiac group of the Los Angeles General Hospital. The changes are proliferation of the intimal endothelium of the intrapulmonary arteries, increase in the intimal connective tissue with vascularization. There is also marked medial hypertrophy with scarring. Less often, there is arteriolar necrosis. As a result, the lumens of the small arteries are markedly reduced. Scattered thrombi also are present in the small arteries. The alveolar walls show dilatation of the capillaries, increase in the thickness of the capillary basement membrane, increase in the interstitial tissue, interstitial precapillary edema and a tendency of the flat epithelial cells to become cuboidal. Clearly, this is not the same process as is present in severe emphysema. The reduced lumens of the arteries and arterioles, which are altered structurally, must cause increased resistance to the flow of blood. In the stage of medial hypertrophy, before scarring has occurred, it is conceivable that the artery retains much of its flexibility and indeed the change might be reversible. This has already been pointed out by Larrabee, *et al.*[8] There is no single factor operating to produce pulmonary hypertension. According to Carroll, *et al.*[2] hypertension may precede other evidence of abnormal pulmonary function, and perhaps under these conditions, it might be assumed that the change is arterial in origin. On the other hand, Gray and Gray[6] found, in 13 cases of mitral stenosis, that 4 showed a deficit in complete arterial saturation, apparently the result of an increased ventilation-diffusion factor, presumably due to the capillary and alveolar lesions. In 2 cases, there was evidence that the deficit was the result, partly, of blood shunted from left to right through collaterals uniting bronchial and pulmonary arteries and between pulmonary and azygos veins.

Fig. 5. Severe change in arteriole.

PULMONARY ARTERITIS IN CONGENITAL HEART DISEASE

The clinician and radiologist are occasionally presented with a patient suffering from a congenital cardiac lesion, in whom the pulmonary artery pressure equals or even exceeds the systemic. Ordinarily, this would suggest a free communication between the pulmonary artery and aorta with an appropriate defect and rotation at the base of the heart to make this anatomically feasible. However, at postmortem, no such communication is found. Through the kindness of Dr. Hans Hecht, we were able

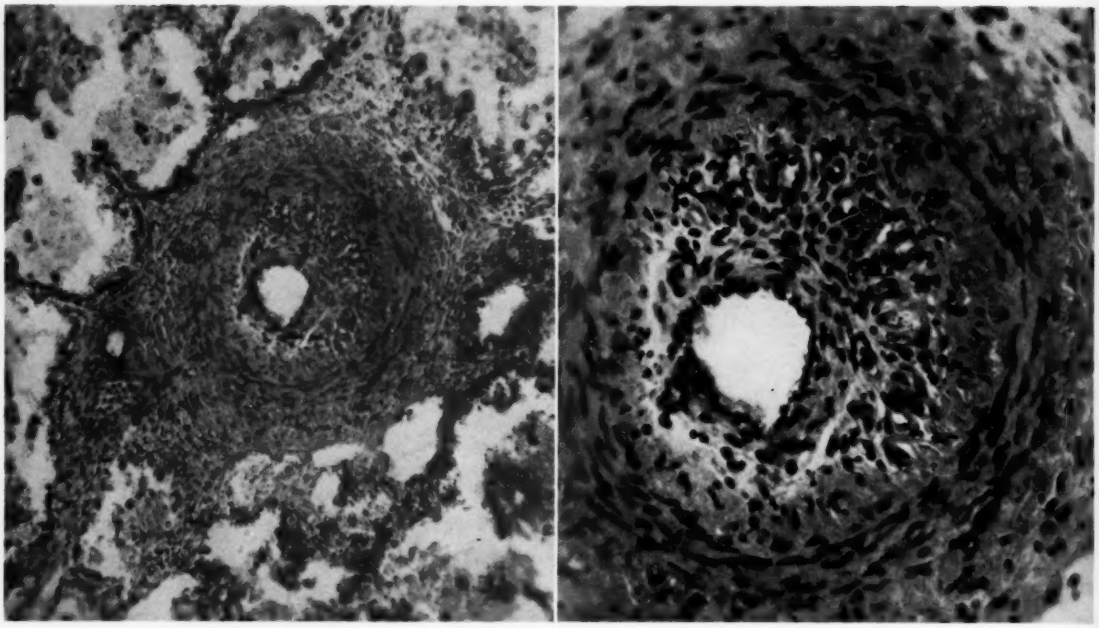

Fig. 6. Small artery in a case of mitral and aortic stenosis showing typical changes of endothelial proliferation with formation of small capillaries in intima. Low and high power.

to study such a case. The only communication between the two sides of the heart was an atrial septal defect demonstrated by the passage of the catheter as well as by angiocardiography. The pathologist described probe patency. The size of the shunt indicated clearly that it alone could not account for the degree of pulmonary hypertension (140/5). Histologic study of the lungs demonstrated a marked arteritis with markedly narrowed arterial lumens. This might be interpreted as an inflammatory reaction, but it seems more likely that in this patient, the thick-walled fetal type pulmonary vessels persisted as a mechanism to prevent flooding the lungs which would otherwise occur with increased flow and pulmonary hypertension. In these muscular fetal arteries, the lumen of the vessel is less than the transverse diameter of the vessel wall. Why this primitive type of vessel persists in some individuals and not in others is unknown. The compensatory mechanism which occurs with the bronchial artery collateralization in some cases of tetralogy of Fallot and all cases of pulmonary atresia will not be discussed.

PULMONARY ANGIOGRAPHY

Histologic examination and the preparation of vascular casts undoubtedly are more definitive in their approach to the problem of these vascular changes. Lung biopsy is carried out more or less routinely during mitral surgery and during some shunt operations. However, a direct study of the vessels, as contrasted with the indirect evaluation by catheterization, is not possible other than through autopsy. Under these conditions, pulmonary angiography makes it possible to obtain some gross information. The difference in the gross appearance of the long, slender and smoothly dividing vessels of emphysema, compared with the irregularly-arborizing vessels in mitral lung, is quite striking. There is a striking diminution in the smaller arterial branches when there is severe pulmonary hypertension. The pulmonary angiogram affords, also, a clear impression of the diversion of blood from diseased pulmonary

tissue. At this time, the results are probably only of didactic value, but further exploration might be rewarding.

It is difficult to believe that in these cases congestion plays an important role. It has been possible at autopsy, in some cases, to state that tuberculosis and histoplasmosis are unlikely causes. It is thought, that at least under these circumstances, they are of rheumatic origin with organization, calcification and ossification of small infarcts or pneumonia.[7]

PULMONARY NODULATION IN MITRAL DISEASE

Our discussion can scarcely be left without a brief note on this subject. In the chronically congested lung, hemosiderin pigment often is abundant in large mononuclear phagocytic cells, called "heart failure" cells found in the alveoli. They form foci predominantly localized immediately below the slightly fibrous visceral pleura in locations related to subpleural lymph nodes. Lung tissue between the foci is apt to be normal. These foci may organize and calcify. If confluent, there is diffuse interstitial fibrosis. On the other hand, occasionally, miliary nodulation is found in a patient with rheumatic heart disease who is not in failure, nor is there any history or indication of past failure. Miliary calcification or ossified nodules are found throughout the lungs.

SUMMARY

1. Seventy-one cases of chronic cor pulmonale examined at postmortem were restudied with special reference to the pulmonary vessels. In 67 of these there was associated pulmonary disease.

2. Twenty-four of the 67 cases showed moderate or severe changes in the arterioles consisting of muscular hypertrophy in the media, subendothelial fibrosis, hyalinization and atheroma. This is in contrast to the finding of simple intimal fibrosis which is "physiologic" and usually is more prominent with advancing age.

3. There was no correlation between these vascular changes and the degree of right ventricular hypertrophy nor with the severity of the clinical findings. The pathologic changes are most likely secondary due to the abnormal physiology rather than a cause of it.

4. Cardiac enlargement as determined roentgenologically is not a feature of chronic cor pulmonale. The right ventricular hypertrophy is ordinarily not demonstrable by roentgen examination. Generally there is no progressive enlargement over years of observation unless there is other concomitant disease; however, when enlargement occurs, severe vascular disease is found in the lungs, and there is clinical evidence of repeated cardiac failure.

5. For comparison, the histologic changes in the pulmonary vessels are described in other conditions such as mitral disease and certain congenital cardiacs.

6. Attention is called to the use of pulmonary angiography in this type of study.

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VOL. 75, NO. 4

A MODIFICATION OF THE ROUTINE LATERAL VIEW OF THE CHEST TO PERMIT VISUALIZATION OF THE SUPERIOR MEDIASTINUM*

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THE purposes of this article are to stress the inadequacy of roentgenography in the present routine lateral view of the chest, and to suggest a modification which may overcome some of the present limitations.

There are two accepted positions for the lateral view of the chest. In one[1,6,9] the patient is placed in the erect lateral posture and both arms are extended over the head. In the other[4,10] the patient is placed in the erect lateral posture and both extremities are locked over head in such a manner that the elbows are bent, and the hand of one side clasps the elbow of the other. Zintheo[12] in a thorough review of all the auxiliary techniques employed in chest roentgenology fails to mention any other variation in position.

Both of these standard lateral techniques are defective in that they create a blind spot in the superior mediastinum. The heads of the humeri, the scapulae and the soft tissues of the shoulders are thrown directly over the superior outlet of the thorax, and all pathologic changes in this region are masked. Obvious pathologic changes readily noted on the postero-anterior roentgenogram, such as a calcified substernal thyroid, are rendered invisible in the routine lateral view. Even more important, pathologic changes which can only be determined in a lateral projection, such as a retrosternal mass, kinking or dilatation of the superior portion of the trachea, or small masses in the superior mediastinum are hidden. It is possible for a competent roentgenologist to render a negative report on a patient who harbors a tumor in his superior mediastinum.

Accordingly some method was sought which would allow better roentgen visualization of this region in the lateral view.

There are two methods of attack on this problem. One is the method of special projections. Many ingenious projections have been devised which cause relative distortion of certain parts of the superior outlet of the thorax, and throw other parts into clear view. Among these may be mentioned the special sternoclavicular joint view,[3] the sternal view,[2] and the inclined lateral or interclavicular view[11] for separate visualization of the apices of both lungs. These views have considerable value for the special study of special structures, but distort the general regional anatomy.

Such an approach, we feel, is not optimal. The superior mediastinum is as much a part of the routine examination of the chest as the heart. A method, we feel, should be devised which should be used routinely in place of the standard lateral technique and which succeeds in demonstrating this area previously accepted as invisible.

Many techniques were tried and studied, particularly the lateral sternal view, the view used by Pancoast and Pendergrass[5] to study the thymus in children and others. The following technique was found to produce results which were satisfactory in a large number of cases.

The patient is positioned in the erect lateral posture and places his hands behind his back, where they are held from behind by an attendant, who clasps the heads of

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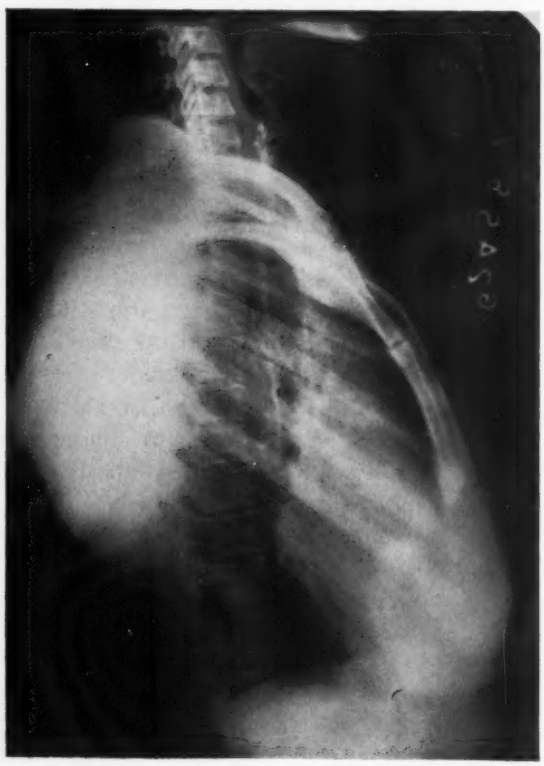
Fig. 1. Improper positioning. Note how the heads of humeri and the soft tissues of the shoulders partially obscure the structures in the superior mediastinum.



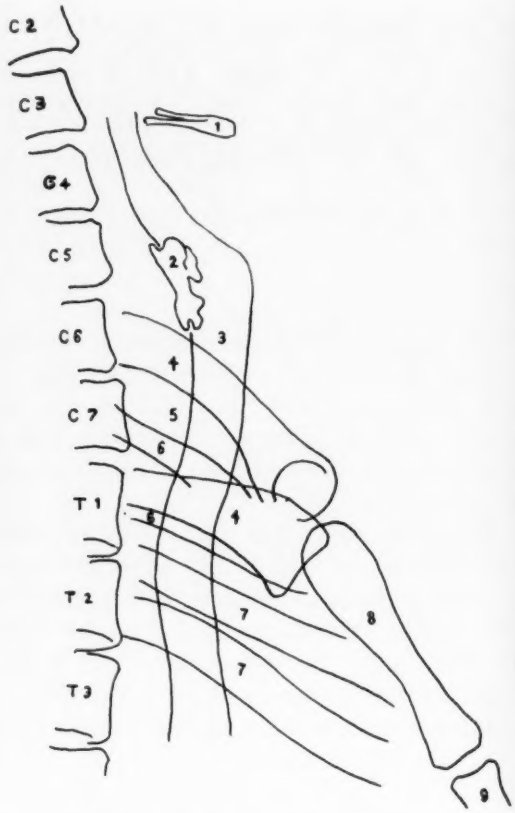


Fig. 3. Labelled tracing of the superior mediastinal portion of Figure 2: 1. hyoid bone; 2. thyroid cartilage; 3. trachea; 4. clavicles; 5. prevertebral space; 6. 1st ribs; 7. 2nd ribs; 8. manubrium sterni; 9. gladiolus sterni.

the patient's humeri, and rotates the shoulders backwards and outwards, out of the way of the superior mediastinum. An unobstructed view of the superior mediastinum is thereby obtained.

A comparison of bad and good positioning in the same patient is shown in Figures 1 and 2. Figure 1 shows the shoulders thrust forward, and partially obscuring the superior outlet of the thorax. Figure 2 demonstrates the correct position of the shoulders, providing an excellent view of the following structures in the outlet of the thorax: sternoclavicular joint, manubrium sterni, thyroid region, retrosternal space, trachea in its entirety, prevertebral space

Fig. 2. Same patient as in Figure 1, correct positioning. The heads of the humeri and the soft tissues of the shoulders have been thrown completely clear of the superior mediastinum.

Fig. 4. Malacia of the trachea caused by tumor invasion from the hypopharynx. Note the marked widening of the tracheal shadow.

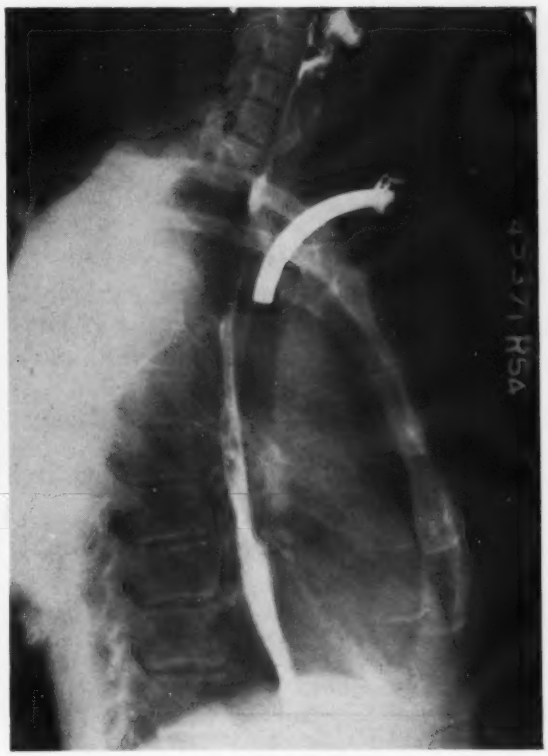


Fig. 5. Carcinoma of the cervical esophagus. Note the widening of the prevertebral space, and especially the enlargement of the space between the trachea and esophagus. These findings, coupled with the slight narrowing of the esophagus, are highly indicative of a space occupying lesion.

and the junction of the lower cervical and upper thoracic vertebrae.

A tracing of Figure 2 is shown in Figure 3 with labels to define the anatomic structures.

REPORT OF CASES

The following cases show the value of the modified lateral technique:

Case 1. *Malacia of the Trachea.* This patient had a proved carcinoma of the hypopharynx which had invaded the wall of the trachea producing partial destruction of the tracheal rings. Endoscopy and biopsy were performed. Note the massive widening of the upper trachea (Fig. 4). The film was exposed in inspiration. Further studies on expiration showed almost complete collapse of the tracheal lumen. This satisfies the criteria for malacia of the trachea as described by Sgalitzer.[8] It is interesting to note that the first clue to tracheal abnormality was noted with the modified lateral technique.

Case 11. *Carcinoma of the Cervical Esophagus.* This patient had a proved epidermoid carcinoma of the cervical esophagus confirmed by endoscopy and biopsy. The unusual feature in this case was that though repeat barium swallows were made in an effort to locate the lesion (because the patient's marked dysphagia directed attention to the esophagus) all roentgen examinations were interpreted as normal, even in the light of the subsequent endoscopic examination. Study in the modified lateral chest position showed a number of roentgen features which allowed the diagnosis to be made. Note the slight narrowing of the esophagus in the prevertebral space at C6–C7. This finding is hardly intrinsically diagnostic, but when coupled with the widening of the prevertebral space and the increase in the esophagotracheal space (the space between esophagus and trachea which should be nonexistent), a diagnosis of space occupying lesion becomes possible (Fig. 5). These findings could not be noted with any special technique which distorted the regional anatomy.

COMMENT

This method has certain obvious limitations: it cannot be used satisfactorily in

patients with kyphosis, it is uncomfortable for the patient, and it often requires exposure on the part of an attendant.

In spite of these limitations, we feel it represents a distinct addition to other methods, and should be used routinely.

SUMMARY

1. A modification of roentgenography in the routine lateral view of the chest is presented which allows visualization of the superior mediastinum.

2. Examples of the value of this technique are given.

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MEDIASTINAL PNEUMOGRAPHY*

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ROENTGEN evaluation of the mediastinal contents is not infrequently a difficult problem. Visualization of certain of the structures is made possible because of the excellent contrast afforded by the adjacent air filled lungs. Additional information is obtained by the use of opaque contrast media within the esophagus, trachea and bronchi, and the heart and great vessels. The introduction of air into the mediastinum itself for contrast purposes has been utilized to a very limited extent and its frequent use not recommended because of the dangers associated with the direct injection of air behind the jugular notch.[2] Benign and malignant neoplasms have been differentiated by this method. The malignant tumors invade and become adherent to the parietal pleura thus preventing separation of the mass from the pleura. In other instances shadows resembling pulmonary and mediastinal tumors have been recognized as being vascular in orgin.

During the course of routine presacral gas injection studies for visualization of the retroperitoneal structures, it became apparent that often sufficient gas ascended through the diaphragm into the thorax to outline the thoracic aorta. Exploitation of this phenomenon resulted in a safely and easily obtained pneumomediastinum. The present study is concerned primarily with the attempt to define more clearly by mediastinal pneumography as many of the normal mediastinal structures as possible. The recognition of variants is of value in differentiating normal from abnormal shadows. Application of the method in 2 cases of mediastinal masses is presented.

ANATOMIC CONSIDERATIONS

In 1950, Ruiz Rivas[3] described the single puncture technique of injecting gas in the presacral region and visualizing the retroperitoneal structures and some of the pelvic and abdominal organs. He stressed the intimate connection and intercommunication of the loose areolar tissue of the retroperitoneal area with the ample cellular tissue of the mediastinum and neck. When sufficient gas is injected into the presacral areolar tissue it readily ascends into the thorax and frequently into the cervical region.

There are apparently four major sites of passage of gas through the diaphragm into the thorax: The areolar tissue surrounding (1) the inferior vena cava, (2) the aorta, (3) the esophageal hiatus, and (4) the loose tissue anteriorly behind the sternum where diaphragmatic fibers originate in the regions of the foramina of Morgagni (Fig. 1).

Gas rising around the inferior vena cava separates the inferior surface of the pericardium from the diaphragm except in the immediate vicinity of the central tendon where the vena cava is intimately attached to the pericardium. This attachment prevents the development of pneumopericardium (Fig. 2). Thus the inferior surface of the pericardium becomes visible whereas ordinarily, on plain films, the heart shadow blends with that of the diaphragm (Fig. 3, *A* and *B*). The lateral, anterior and posterior margins of the heart are normally sharply defined by the adjacent air filled lungs but become even more distinct when outlined by a fine layer of gas encircling the pericardium. As the gas extends upward, it surrounds the ascend-

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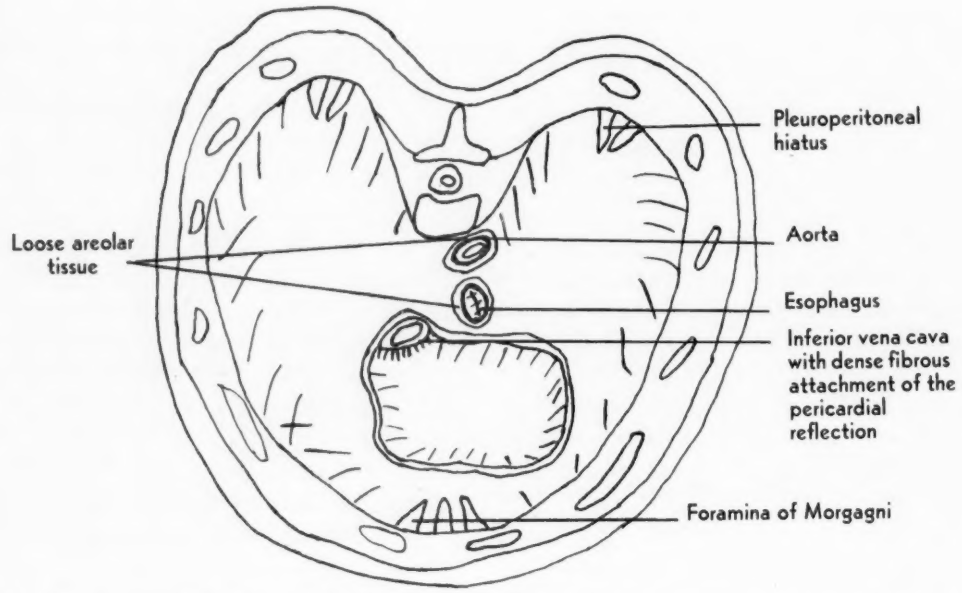

Fig. 1. Cross-section at the level of the diaphragm (schematic) to illustrate diaphragmatic openings.

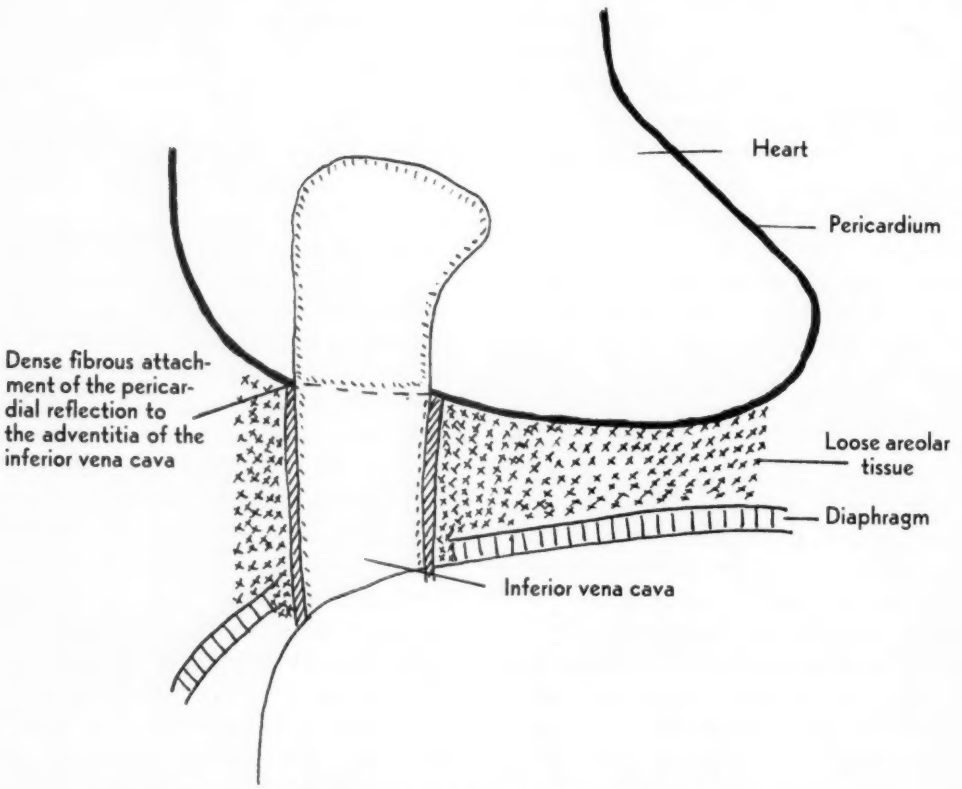
Heart
Pericardium
Dense fibrous attachment of the pericardial reflection to the adventitia of the inferior vena cava
Loose areolar tissue
Diaphragm
Inferior vena cava

Fig. 2. Diagram of the pericardial reflection about the inferior vena cava

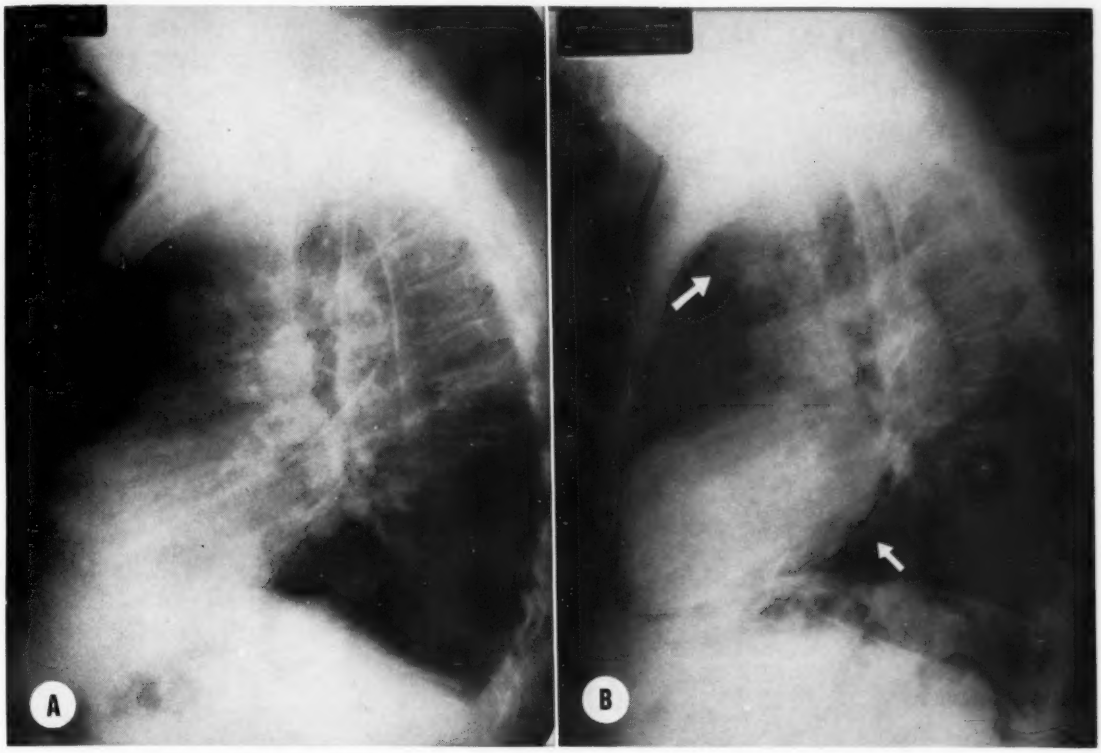

FIG. 3. (*A*) Lateral exposure of the chest before injection of oxygen. (*B*) Lateral exposure of the chest following the injection of 1,000 cc. of oxygen by the presacral route. Gas surrounding the pericardium is demonstrated, with sharp definition of the anterior, posterior, and inferior margins. Also visualized are the knob-like projection of the superior vena cava (upper arrow), the posterior margin of the proximal thoracic aorta, and the soft tissue density of the esophagus just posterior to the heart (lower arrow).

ing aorta and superior vena cava and these structures are visualized. The lateral margin of the superior vena cava is frequently delineated on the posteroanterior exposure (Fig. 4). The ascending aorta as it emerges from the cardiac shadow is best demonstrated on the lateral exposure (Fig. 5). This segment of the aorta is commonly difficult to outline on plain film studies. The occasional knob-like contour of the superior vena cava that has been demonstrated on lateral exposures during angiocardiography may also be seen (Fig. 3*B*).

The entire descending thoracic aorta is brought into sharp focus by the gas which ascends through the aortic hiatus. The upward extension of the gas outlines the aortic arch and as the apex of the arch is reached there is apparent blending with the gas surrounding the ascending aorta. The superior margin of the aortic arch is usually better defined than is the inferior margin (Fig. 5).

The soft tissue shadow of the lower portion of the esophagus above the level of the diaphragm in the retrocardiac area is frequently visualized and occasionally almost the entire thoracic portion of the esophagus can be seen. This is only recognized on the lateral exposure as the esophagus is hidden by the cardiac mass on the posteroanterior view (Fig. 3*B* and 5).

The loose areolar tissue space behind the lower end of the sternum is readily outlined and from this site the gas ascends extrapleurally behind the sternum (Fig. 5). No gas passes into the pleural spaces because of the nature of the pleural reflections. Further extension of the gas into the cervical region may occur (Fig. 4*B* and 6).

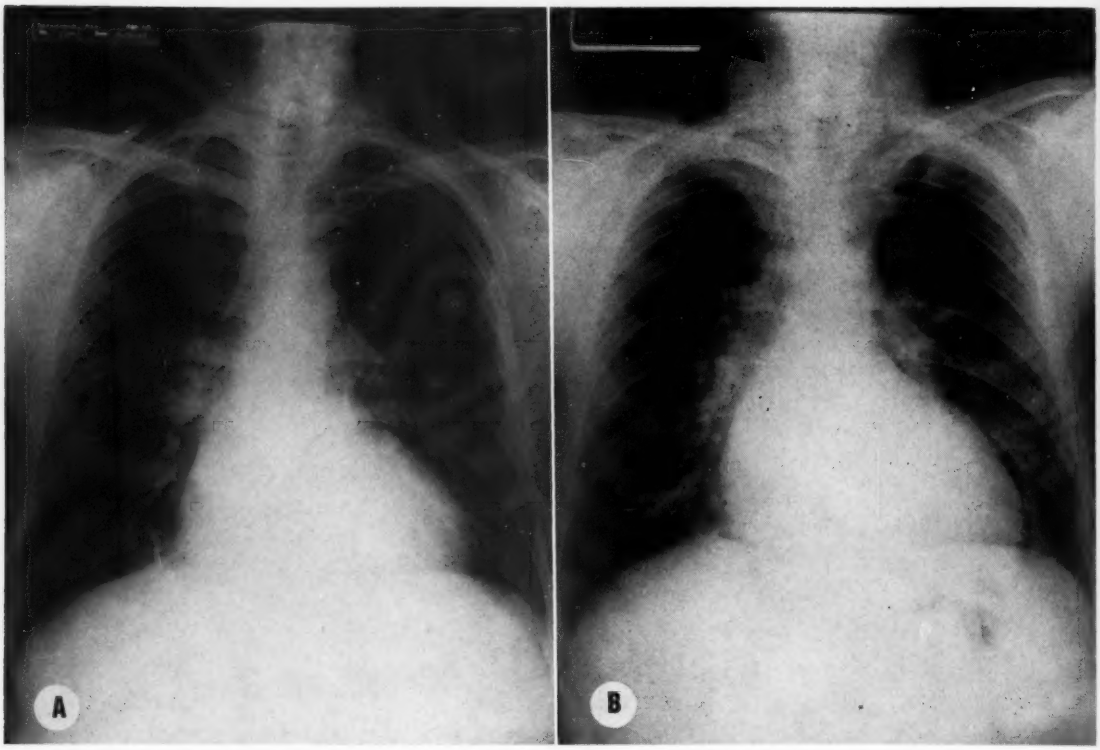

Fig. 4. (*A*) Posteroanterior exposure of the chest prior to injection of oxygen. (*B*) Posteroanterior exposure of the chest following the injection of oxygen. The lateral margin of the superior vena cava is sharply defined. The right and left heart borders are clearly outlined by a fine layer of oxygen. Streaks of gas are noted in the cervical region (arrow).

DIAGNOSTIC APPLICATIONS

Recognition of the normal mediastinal structures and their variants is a prerequisite to the accurate evaluation of suspected abnormalities. Conditions that may advantageously lend themselves to study by mediastinal pneumography include: mediastinal tumors, cardiac tumors, pericardial cysts and tumors, aortic aneurysm, ventricular aneurysm, coarctation of the aorta and possibly selected types of congenital heart disease. The procedure is much simpler to perform and less hazardous than either angiocardiography or aortography. When evaluation of the thoracic aorta is specifically desired a satisfactory pneumogram of the mediastinum may be sufficient for adequate interpretation. Recourse to opacification of the aorta will, of course, be necessary in many instances. A preliminary pneumogram, however, may obviate the necessity for opacification in a significant number of patients.

REPORT OF CASES

Case 1. A fifty-four year old female patient complained of a non-productive mild cough for approximately three months. Roentgenographic examination of the chest disclosed a large anterior mediastinal mass (Fig. 7). The ascending aorta could not be visualized. There was no evidence of pulsation of the mass and fluoroscopically it was not possible to separate this shadow from the heart and ascending aorta. Mediastinal pneumography was performed and the shadow of the ascending aorta visualized (Fig. 8). Exclusion of aortic aneurysm was therefore possible. It was also obvious that the gas failed either to outline the anterior margin of the heart or ascend extrapleurally behind the sternum. A diagnosis of malignant neoplasm was entertained and the possibility of a thymoma suggested. At operation a firm mass intimately associated with the pericardium

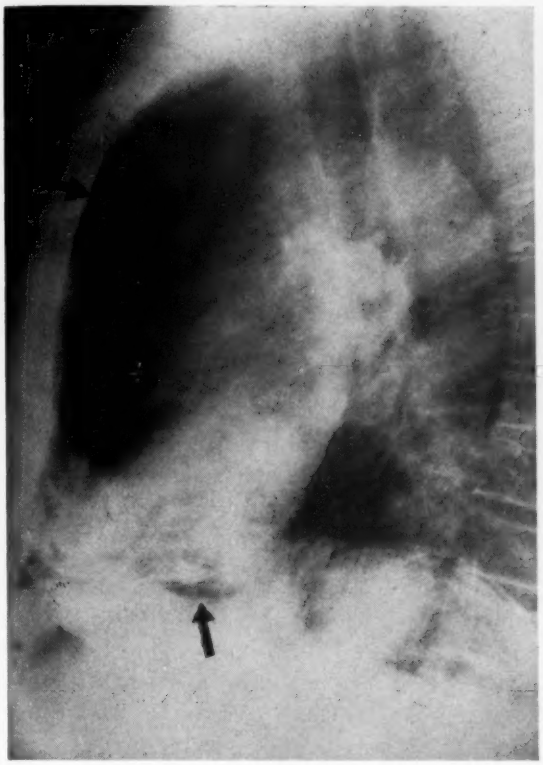

Fig. 5. The anterior margin of the ascending aorta is sharply defined as it arises from the cardiac mass. The entire arch and descending aorta are clearly visualized. The soft tissue shadow of the esophagus can be seen posterior to the heart above the diaphragm. There is some separation of the base of the heart from the diaphragm (lower arrow) and the oxygen has entered the retrosternal spaces (upper arrow).

and great vessels was found. It was possible by dissection to remove the tumor. The microscopic report was malignant thymoma of the Hodgkin's variety.

Case II. A sixty-one year old male patient complained of a cough for approximately four months. Roentgenographic examination of the chest disclosed a left posterior mediastinal mass displacing the esophagus to the right and posteriorly (Fig. 9). Fluoroscopically it was not possible to separate the shadow from that of the arch of the aorta. There was no definite expansile pulsation. In an effort to differentiate aneurysm from tumor, mediastinal pneumography was performed followed by angiocardiography. A normal faintly opacified aortic arch was demonstrated encircled by a fine layer of gas (Fig. 10). Subsequent exploration disclosed an inoperable bronchogenic carcinoma.

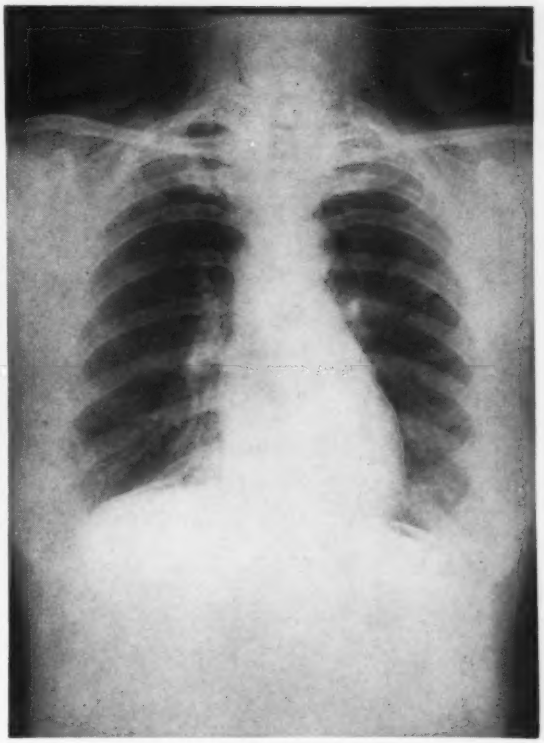

Fig. 6. Extensive cervical gas following the presacral injection of 1,200 cc. of oxygen.

In both instances cited above pneumomediastinum was of value in differentiating tumor from aneurysm. In one instance a correct impression of malignant rather than benign neoplasm was obtained.

TECHNIQUE

Our technique is a modification of that generally used in retroperitoneal pneumography for visualization of abdominal structures.[1,3] Oxygen is used instead of air because of its more rapid absorption and decreased danger of air embolism. Carbon dioxide may be used but its very rapid absorption requires rapid film taking and precludes follow-up study at varying time intervals.

With the patient standing before a waist-high table, the trunk is bent forward so that the left shoulder rests on the table. The skin is prepared with a suitable antiseptic and a wheal is raised with 1 per cent procaine, 1 cm. lateral to the sacrococcygeal junction. A no. 20 gauge spinal

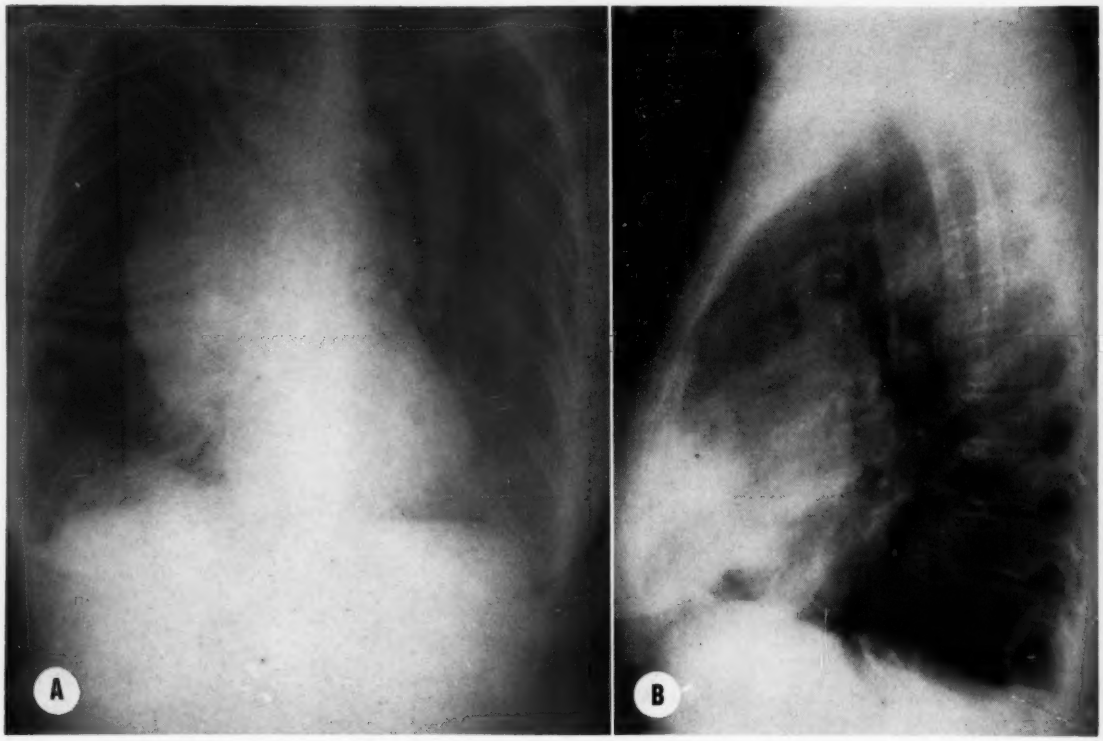

Fig. 7. Case 1. (*A*) Posteroanterior exposure demonstrating large right sided mediastinal shadow obscuring the right heart border. (*B*) Lateral exposure disclosing the anterior position of the shadow blending with those of the heart and ascending aorta.

Fig. 8. Case 1. Following mediastinal pneumography the anterior margin of the ascending aorta is clearly demarcated and aneurysm of the aorta can be excluded. Note the failure of the gas to outline the anterior margin of the heart or to seep into the retrosternal space (compare with Figure 5). This appearance suggests malignant infiltration.

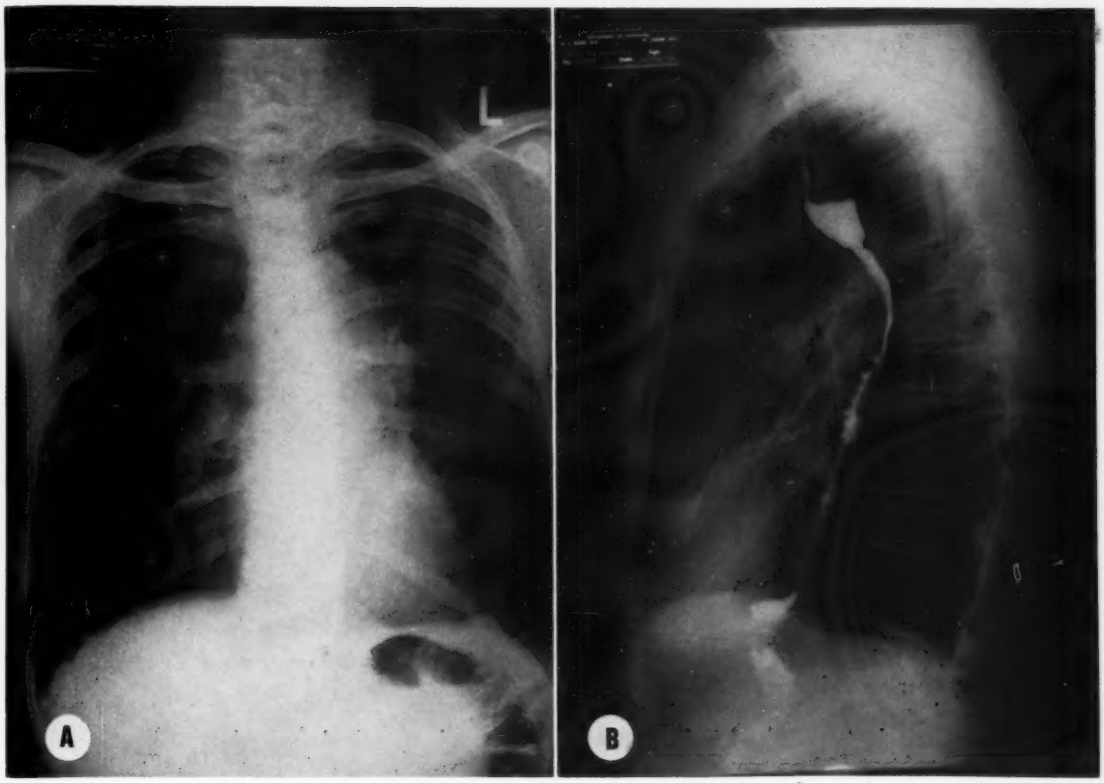

Fig. 9. Case 11. (*A*) Routine posteroanterior exposure of the chest demonstrating a mass in the region of the left hilus. (*B*) Routine lateral exposure showing the mass anterior to the esophagus and superimposed on the shadow of the proximal descending aorta. This shadow cannot be definitely separated from that of the aorta roentgenoscopically.

puncture needle with a stylet is then inserted, directed medially, forward and upward, and guided into position with a gloved finger in the rectum. The needle point comes to rest in the avascular space between the rectum anteriorly and the sacrum behind. The stylet is removed and, following aspiration to insure that the needle is not within a blood vessel, 1 to 1½ liters of oxygen are injected, depending on the size of the patient.

The predetermined volume of oxygen under atmospheric pressure is displaced by an equal volume of water and injected through plastic tubing attached to the spinal needle by an adapter. The pressure gradient to displace the water is supplied by a standard oxygen tank. To avoid the danger of water being forced into the tissues a flotation type safety valve is incorporated into the system. The time required for injection is three to five minutes.

During the procedure the patient experiences a slight amount of pressure discomfort, especially in the flanks. In some cases a cervical subcutaneous emphysema and change in voice quality have been noted. None of these side effects has been particularly distressing and they disappear within several hours. Occasionally oxygen has remained in the retroperitoneal and mediastinal tissues for as long as three to four days.

Film exposure is delayed for approximately fifteen minutes during which time the patient is instructed to walk about to facilitate the upward diffusion of the oxygen. Erect posteroanterior and lateral views of the chest are taken routinely and oblique projections added if necessary. Bucky tecnique is advantageous for the lateral and oblique exposures. If the ab-

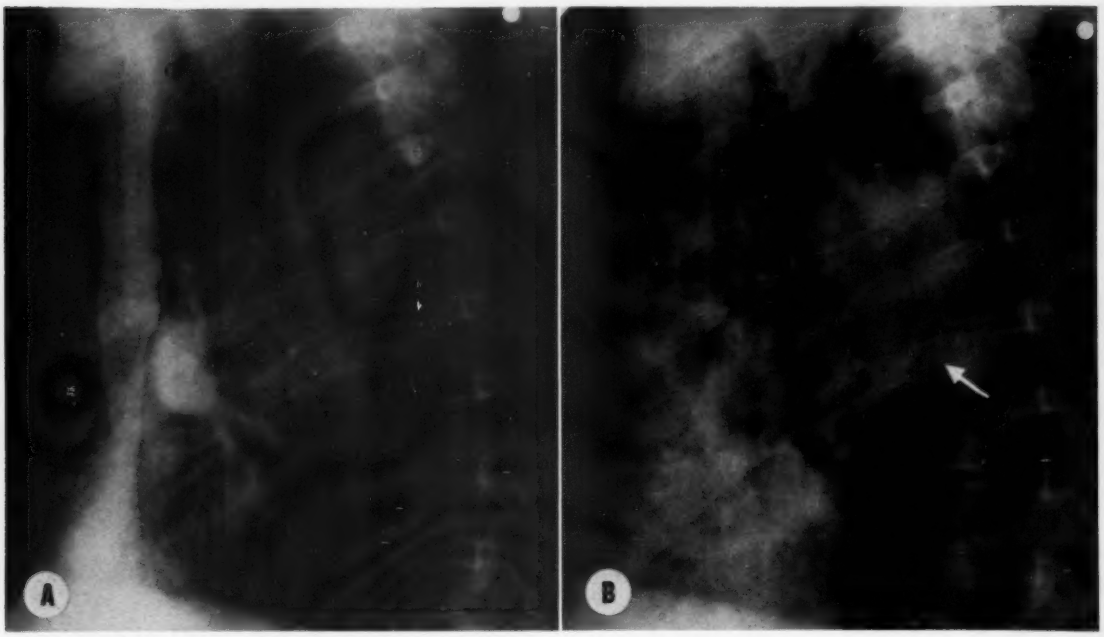

Fig. 10. Case 11. (*A*) Combined pneumomediastinum and angiocardiography. One second after the injection of 50 cc. of 70 per cent diodrast the superior vena cava, right heart, and pulmonary artery are visualized. (*B*) Combined pneumomediastinum and angiocardiography. Eight seconds after the injection of contrast material the aorta is well outlined and a fine layer of oxygen is visualized separating the inner aspect of the aortic arch from the tumor mass (arrow). Subsequent pathologic study confirmed the diagnosis of primary bronchogenic carcinoma.

dominal structures also are to be studied films of the abdomen are exposed in the prone, supine, and erect positions as well as in various oblique and lateral decubitus positions.

SUMMARY

1. Pneumomediastinum can be produced safely and easily by the presacral injection of oxygen or carbon dioxide.

2. The normal mediastinal structures can be more clearly demonstrated by gas contrast.

3. Pneumomediastinum proved to be useful in differentiating mediastinal tumors from aneurysm of the aorta in 2 cases. In 1 of these cases the procedure led to the proper interpretation of a malignant rather than benign neoplasm.

4. The use of mediastinal pneumography in the diagnosis of certain developmental anomalies and pathologic conditions of the mediastinum, heart and great vessels is suggested.

5. A simple method of producing pneumomediastinum is described.

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Vol. 75, No. 4

ROENTGENOLOGIC METHOD FOR DEMONSTRATION OF BRONCHOPULMONARY SEGMENTS IN FULLY EXPANDED CADAVER LUNGS IN SITU*

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ALTHOUGH the lung structure has been subjected to considerably study since the early days of medicine, it was not until 1880, when C. T. Aeby[2] published his textbook on the mammalian bronchial tree, that the foundation work was laid for the phylogenetic interpretation of pulmonary anatomy. Ewart[10] in 1889, by careful dissection and injection of metal with a low melting point, recognized the fact that the lung must be divided into smaller antomic entities than the lobes, which he called "bronchial districts." The significance of their work on bronchial structures was not recognized until recently; however, present day investigation reveals that their anatomic description can only be improved upon in minor details. Kramer and Glass,[22] bronchoscopists (1932), in presenting a method of localizing lung abscess, although unaware of Ewart's work, felt the necessity to establish a smaller and more accurate unit of localization than the lobe. They first employed the name in current usage "bronchopulmonary segments."

Following the recognition of the bronchopulmonary segments a number of investigators have published the results of their own works and observations. Among them are Levitin,[24,25,27] and Levitin and Brunn,[26] Hardie-Neil, Gilmour and Gwynne,[14] Hardie-Neil and Gilmour,[15] Baarana, Dirken and Huizinga,[4] Behr and Huizinga,[5] Huizinga and Behr,[18] Huizinga,[19] Pothoven and Huizinga,[32] Adams and Davenport,[1] Foster-Carter,[11,12] Foster-Carter and Hoyle,[13] and others.[3,16,17,23,29,30,33–41] Miller's[31] textbook has further clarified the concepts of the fundamental lung structures. Also, the very detailed description on pulmonary anatomy with particular reference to surgery of lung abscess has been published by Brock[7,8,9] in his monograph on the bronchial tree. Recently Boyden[6] and his co-workers have made exhaustive studies on the prevailing pattern of segmental bronchi of each lobe and their variations with injection and dissection methods. The simplest and most widely accepted terminology, in the United States, on bronchopulmonary segments is that given by Jackson and Huber,[20] and Jackson and Jackson,[21] which is based on the relative position of the segments within the lobes.

The present method of describing bronchopulmonary segments by their boundaries on the parietal surface of the lung bears little or no correlation with the roentgen shadow of the various segments in standard roentgen-ray projections.

Most investigations have dealt with the postmortem study of collapsed lungs out of the thorax in which case all relationships to chest cage, mediastinal structures are lost.

Furthermore the detailed anatomic descriptions as to length and diameter of the various bronchi provide little useful information in the roentgen interpretation of bronchopulmonary disease.

Even in the roentgenologic literature,[20,21,22] there are marked differences of opinions as to the location and appearance of the segments in both posteroanterior and lateral views.

In view of these obvious limitations and discrepancies, it is felt that a new method for studying the roentgenologic appearance of bronchopulmonary segments is desirable.

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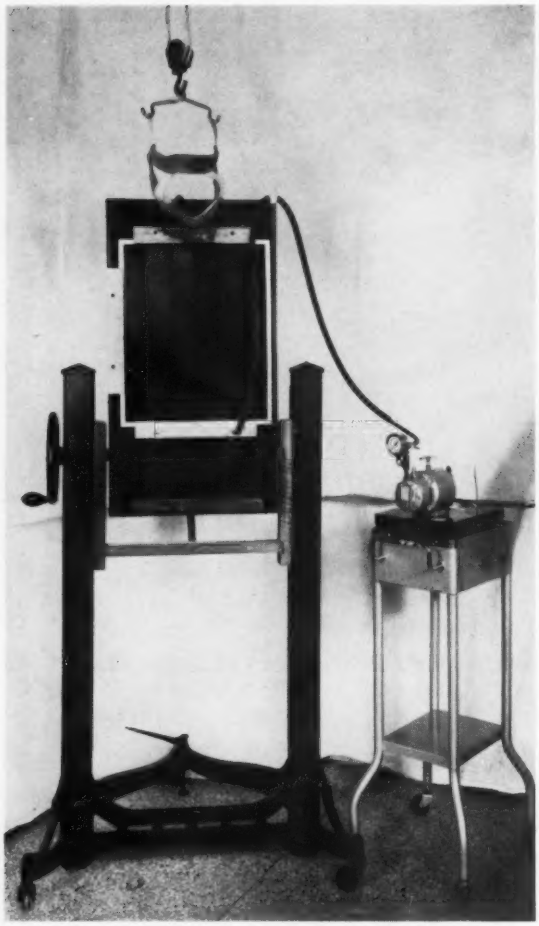

Fig. 1. Cassette holder, pressure apparatus, pulley and head halter.

METHOD OF PRESENT STUDY

Source of Material. Postmortem patients who had little, if any, respiratory involvement were selected for the study. Preferably the lungs from cardiac, traumatic or cerebral accident cases were chosen.

Equipment.

(1) Roentgen apparatus: A Westinghouse portable roentgen-ray unit with 120 kv. peak and 50 ma.

(2) Upright cassette holder, head halter and hoisting pulley.

(3) An (Gomco Surgical MFG Corp., Model No. 789) ordinary suction apparatus was converted in the hospital machine shop to a pressure pump with a 25 pound capacity. A manually operated air pump was tried but found to be inadequate.

(4) Fifty cc. Luer-Lok syringe and an instrument set for dissection of the bronchi and bronchioli.

(5) Contrast medium. Seventy per cent urokon solution with water soluble color paste (Sero-Tone®).

Figure 1 shows the cassette holder, head halter, pressure apparatus and pulley.

Procedure. The bronchi and the bronchioli of the lungs are bluntly dissected free with minimal possible damage to the adjacent lung tissues. One bronchiolus of a certain bronchopulmonary segment is selected and ligated with silk sutures. A cannula corresponding to the diameter of the bronchiolus is inserted into the bronchiolus distal to ligature and is secured in the lumen by a second ligature. The opaque solution is then injected into the segment through the cannula. The cannula is then withdrawn and the bronchiolus is ligated to prevent back leakage of the opaque material. A rubber tube is inserted through the mouth into the upper portion of the trachea. The trachea is secured to the tube by a ligature. The sternum is replaced in position and pericardium sutured to the sternum. The cadaver is erected by means of pulley against a 14 by 17 in. cassette holder. The lungs of the cadaver are then fully inflated through the rubber tube, by means of an electric air pressure pump. A control switch on the pump serves to regulate the speed of inflation. Roentgenograms of the chest in posteroanterior and lateral views are then obtained.

RESULTS AND COMMENTS

Although not all segments were studied, this experiment indicates that the method is useful in demonstrating the appearance of bronchopulmonary segments roentgenologically. Three illustrative cases were selected and are shown in Figures 2, 3, and 4.

The following suggestions are made to those who may in the future attempt fur-

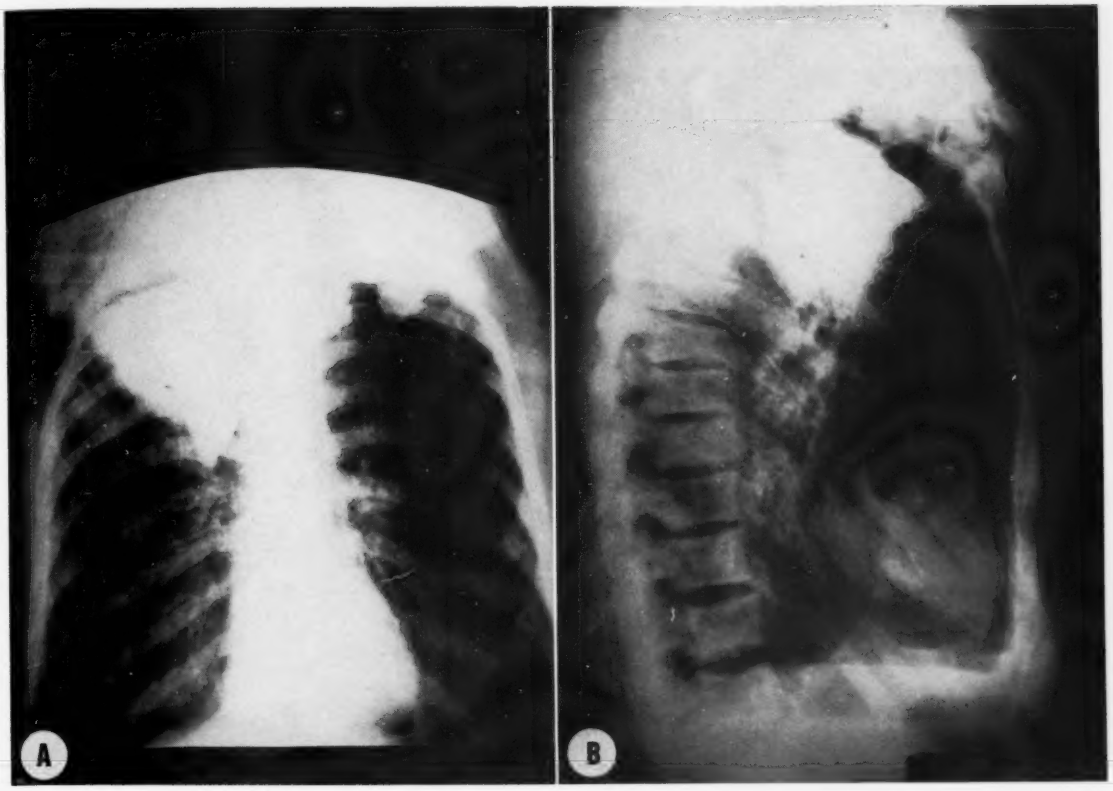

FIG. 2. Case I. Apical segment of right upper lobe. (*A*) Posteroanterior view. (*B*) Right lateral view. The patient died from prostatic carcinoma with metastasis to the bones. The lungs were negative.

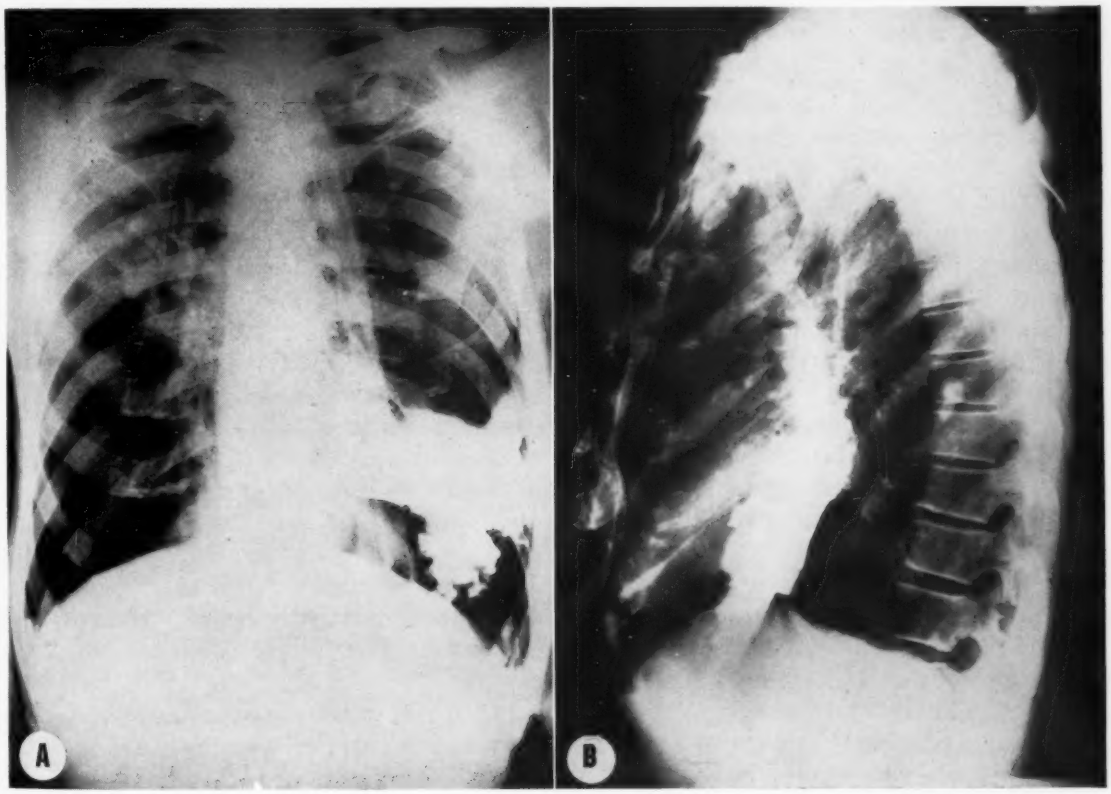

FIG. 3. Case II. Inferior lingular segment of left upper lobe. (*A*) Posteroanterior view. (*B*) Left lateral view.

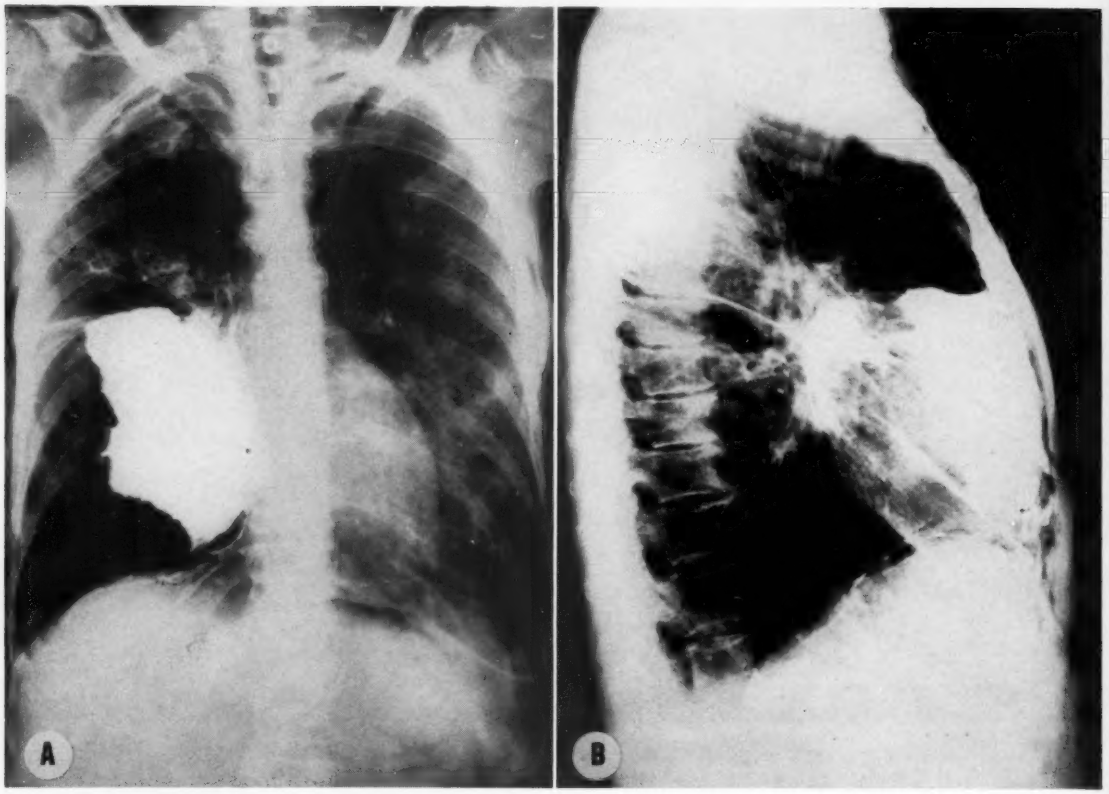

Fig. 4. Case III. Medial segment of right middle lobe. (*A*) Posteroanterior view. (*B*) Right lateral view.

ther study of bronchopulmonary segments by this method and who might profit by the experience obtained from this experiment.

(1) Careful blunt dissection of the bronchi and bronchioli is most essential for a complete expansion of the lungs. Accidental puncture of the bronchi leads to incomplete expansion of the lungs and mediastinal emphysema which vitiates the specimen for study.

(2) The amount of opaque material to be used is sometimes difficult to determine. It is best to observe the segment and stop further injection as soon as the entire segment is colored.

(3) It is important to do the dissection and injection intrathoracically. Cutting and ligating pulmonary arteries and veins should be kept at a minimum to prevent disturbing the anatomic relationship of the lungs and mediastinal structures.

(4) *In situ* examination is basic for a true appearance of the segment. To remove the mediastinum and the lungs and place them in a phantom thorax frequently results in distortion of the segment.

(5) Prior to the intrathoracic dissection, it is advisable for the investigator to familiarize himself with dissection of the bronchi and bronchioli on a few lungs outside the thorax.

(6) The time consumed from the opening of the thorax to roentgenographic exposure is about one to two hours. Thus, close cooperation with the staff of the pathology department is desirable.

CONCLUSION

(1) A brief review of the early investigations of bronchopulmonary segments is presented. The major defects are discussed.

(2) A new method of demonstrating the bronchopulmonary segments roentgenologically by means of intrathoracic dissec-

tion and injection is described. Roentgenograms of three representative cases, in which the method was used, are presented.

(3) It is believed that this procedure affords a satisfactory means for the roentgenographic investigation of segmental anatomy and further study is warranted.

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BI-AXIAL ROENTGENKYMOGRAPHY*

AN AID IN DIFFERENTIAL DIAGNOSIS OF SOLID MEDIASTINAL TUMOR AND ANEURYSM

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THE invention of roentgenkymography is credited to Sabat.[8,11] Since the time of his first publication of this method, extensive exploration and modifications have been made and published in in the world literature.[1,5,9–12] The most important modification was the substitution, by Stumpf, of the multiple slit for the single slit apparatus.[11,12]

Among the physiologic and anatomic applications of roentgenkymography, the problem of differential diagnosis of aneurysm and solid tumor in the thorax has been prominent. In most such problems the diagnosis can be correctly achieved by fluoroscopy and by careful study of roentgenograms made with appropriate positioning of the patient, supplemented by the Valsalva and Müller maneuvers. In some cases, the use of conventional roentgenkymography and/or contrast angiography, has yielded decisive information.

Limitations of the foregoing methods are especially evident in cases involving small aneurysms or tumors and in partly thrombosed aneurysms. Differentiation between expansile and transmitted pulsations may be uncertain;[2,3,4] amplitude of aneurysmal pulsations may be sharply diminished; the Valsalva and Müller maneuvers may not cause appreciable changes in size of the aneurysm containing a large thrombus. Roentgenkymographic wave forms may be so altered in thrombotic aneurysms as to resemble the blunted or pyramidal forms usually seen in solid masses close to the large vessels or heart.[4] Even the density changes of the waves may be difficult to appreciate in the small or thick-walled aneurysm.[10]

Contrast angiography is of value in solving these problems in most cases, but may be misleading if an aneurysm has too small a neck to permit an adequate amount of contrast medium to enter, or if its entrance is obstructed by thrombus. One must also consider the need for a serial-filming device, and the slight but definite morbidity associated with the use of the contrast media now available.

METHOD

It appeared to us that the essential difference between the expansile pulsation of a vascular mass and the transmitted pulsation of a solid mass lay in the inability of the transmitted pulsation to occur in more than one direction at any one time. Thus, to simplify this difference, we may consider a mass which, on roentgenograms and during fluoroscopy, is seen to lie immediately adjacent to the aorta. If it is an aneurysm, it will show pulsations horizontally and vertically at its margins simultaneously. Expansion and contraction should be demonstrable in any other chosen planes, similarly. If, however, the mass is solid, it should exhibit its transmitted pulsations in one direction only, and almost surely not at a right angle to that direction.

It follows that if two kymograms are made, one with the grid slits horizontal, the other with the slits vertical, expansile vascular wave forms should be seen in both films but transmitted pulsations

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should be seen in only one of the two film records. One of us first applied this method during examination of a patient (Case 1) for whom fluoroscopy by several observers failed to be conclusive with respect to the type of pulsations observed. Success in this case led us to try it in some subsequent problems of this type. Review of the literature then revealed that Meyer had made a similar suggestion, recommending that the grid be moved in two oblique planes across the chest; he did not publish illustrative cases.[6] It is essential to choose that position of the patient which will best show the mass in question against the adjacent radiant lung field; this position is determined during fluoroscopic examination, and is used thereafter for kymography with the grid slits in the vertical and horizontal axes.

Roentgenkymography, with the slits vertical, has been used for studies of movements of the thoracic structures, the movements of calcified aortic and mitral valves, and activity of the diaphragm, among other problems.[7,9]

REPORT OF CASES

Case 1. L.S., a fifty-eight year old male, was first examined in the Out-Patient Department of our hospital on May 2, 1951. *Chief complaints:* cough, shortness of breath on exertion, weakness. *Present illness:* the onset of these symptoms occurred in 1936, following an upper respiratory infection and recurred with each respiratory infection since that time. *Past history and family history:* not significant. *Physical examination:* pertinent findings in the chest were consistent with pulmonary emphysema. *Laboratory data:* serology was positive. Other laboratory data were not noteworthy. *Roentgenologic examination:* roentgenograms of the chest (Fig. 1, *A* and *B*) revealed evidence of previous inflammatory disease of the lungs, manifested by fibrotic strands and discrete nodules in both upper lobes and in the left lower lobe. There was a right diaphragmatic adhesion. The heart was small. There was a discretely-outlined soft tissue mass in the anterior mediastinum, projecting to the right of the midline, and displaying a somewhat pyramidal lateral margin. It was immediately adjacent to, and partly overlay, the ascending aorta. Anteriorly there appeared to be soft tissue reflection from the mass to the thoracic wall.

The mass was 3 cm. in diameter (lateral view). During fluoroscopy, it was not possible to separate completely the anterior mediastinal mass from the aorta or from the anterior thoracic wall in any position. The mass pulsated obviously, but distinction between transmitted and expansile pulsation was not made to the satisfaction of the examiners. Therefore, differentiation between a small aortic aneurysm and mediastinal soft tissue tumor, which might be related to the pulmonary nodules, was not certain.

Bi-axial kymography (Fig. 1, *C* and *D*) in posteroanterior and left anterior oblique positions, demonstrated pulsations of the superior, inferior and lateral margins of the mass. The waves were synchronous in time and identical in form with those of the aorta. *Roentgen diagnosis:* aortic aneurysm. *Subsequent course:* thoracotomy was performed on September 20, 1951. The aneurysm was identified and covered with cellophane acetate strips. The postoperative course was satisfactory, and the patient was in good condition at the time of his last visit to the clinic on August 20, 1952.

Case 11. R.S., a sixty year old male, was admitted to our hospital on September 24, 1951. *Chief complaint:* hoarseness for one month. *Present illness:* no cough, no weight loss and no fever had occurred. *Past and family history:* not significant. *Physical examination:* temperature, pulse and respirations were normal; blood pressure was 140/85. There was a left recurrent laryngeal nerve paralysis. No other abnormal findings of significance were recorded. *Laboratory data:* serology was negative. Other data were not contributory. *Roentgenologic examination* (Fig. 2*A*): there was a soft tissue mass in the mediastinum projecting to the left with a sharp, convex, lateral border. It lay adjacent to the descending limb of the aortic arch. It displayed moderate pulsations, synchronous with those of the aorta, but of indeterminate type.

Bi-axial kymography (Fig. 2, *B* and *C*): shallow, blunt waves were revealed along the lateral border of the mass without density changes. No pulsations were detected along the superior border of the mass. *Roentgen diagnosis:* solid mediastinal tumor. *Course:* thoracotomy re-

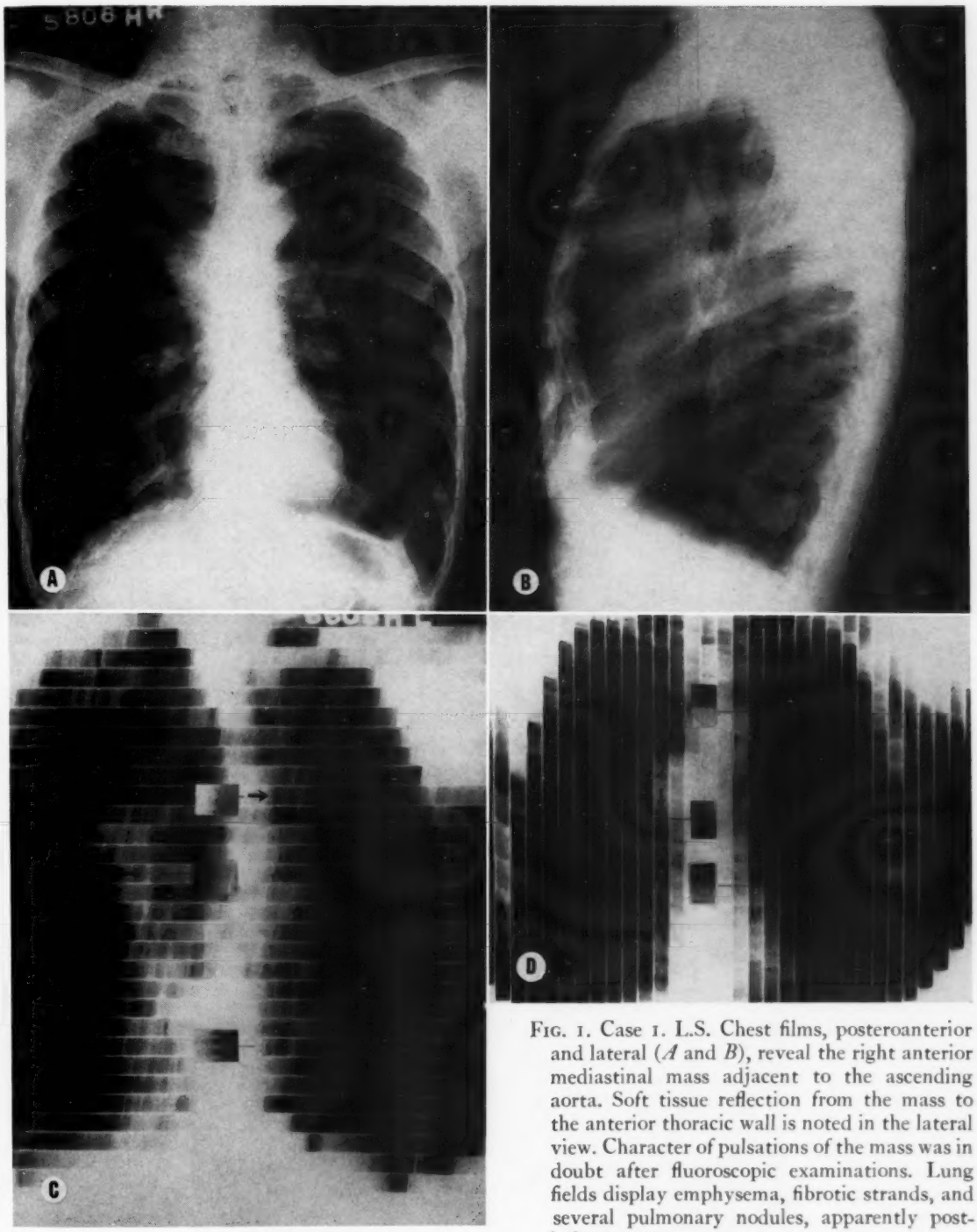

Fig. 1. Case 1. L.S. Chest films, posteroanterior and lateral (*A* and *B*), reveal the right anterior mediastinal mass adjacent to the ascending aorta. Soft tissue reflection from the mass to the anterior thoracic wall is noted in the lateral view. Character of pulsations of the mass was in doubt after fluoroscopic examinations. Lung fields display emphysema, fibrotic strands, and several pulmonary nodules, apparently post-inflammatory.

Horizontal and vertical kymograms (*C* and *D*) show aortic-type pulsations along the inferior and antero-lateral borders of the mass. Posteroanterior and left anterior oblique positions were used. Upper and lower arrows, aorta and left ventricle. Middle arrow, mass (aneurysm). Insets are magnified 2× and retouched.

vealed a solid mass infiltrating the mediastinum and attached to the arch of the aorta. It was not resectable. Tissue was removed for biopsy. *Final diagnosis:* anaplastic carcinoma, left hilus. *Subsequent course:* the patient died at home in February, 1952.

Case III. G.A., a seventy-six year old male was first seen in our Out-Patient Clinic September 4, 1951. *Chief complaint:* bloody urine. *History:* non-contributory. *Physical examination:* no significant chest findings. There was a Grade III prostatic hypertrophy. *Labora-*

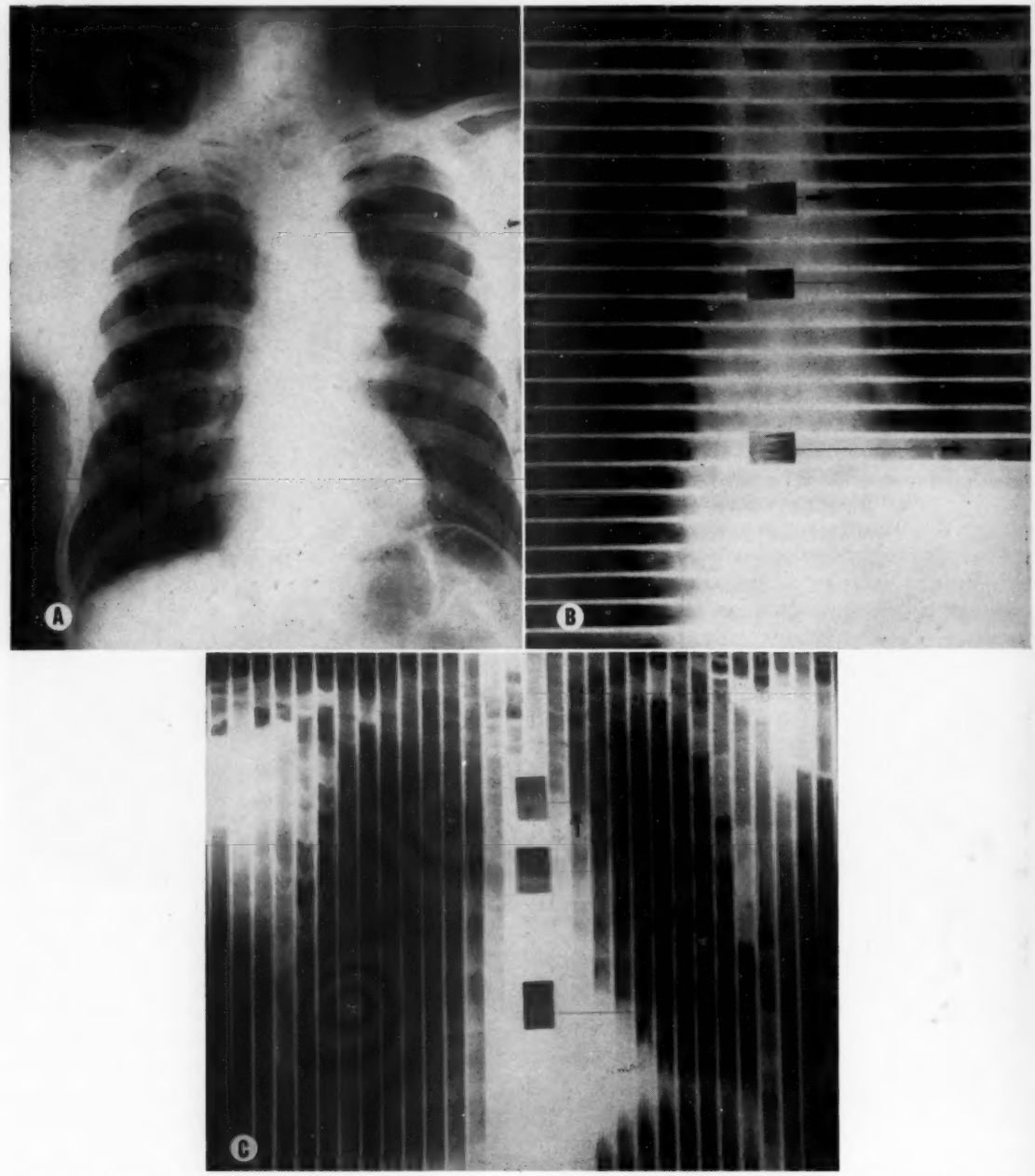

Fig. 2. Case II. R.S. (*A*) There is a mass in the left paramedian zone overlying the left lung hilus and descending aorta. The left hemidiaphragm is elevated. Fluoroscopy revealed shallow pulsations of the mass, probably transmitted. (*B* and *C*) Bi-axial kymograms reveal shallow, blunted waves only laterally, not superiorly, confirming the impression that they represent transmitted pulsations. Upper and lower arrows, aorta and left ventricle. Middle arrow, mass (neoplasm). Insets magnified 2× and retouched.

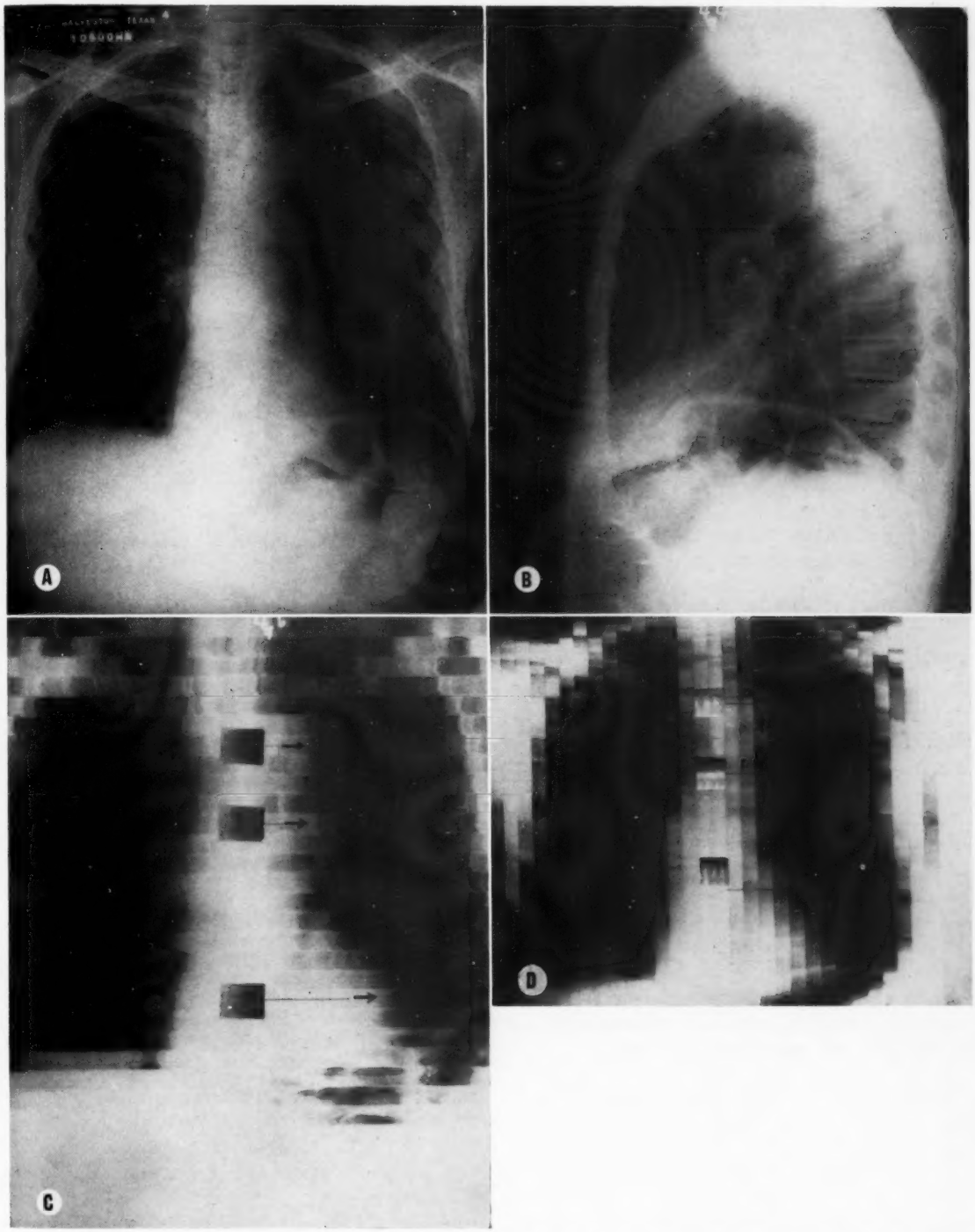

Fig. 3. Case III. G.A. (*A* and *B*) There is a round left hilar soft tissue shadow; roentgenographically and fluoroscopically, it appeared to represent the left pulmonary artery. There is slight elevation of the left hemi-diaphragm. (*C* and *D*) Bi-axial kymograms demonstrate arterial-type waves along the lateral and superior margins of the left hilar mass. Upper and lower arrows, aorta and left ventricle. Middle arrow, left hilar mass (left pulmonary artery). Insets magnified 2×.

tory data: leukocytosis of 22,000 white blood cells; the differential count was not significant. Serology was negative. *Roentgen examination* (Fig. 3, *A* and *B*): the aorta was elongated and tortuous. A round soft tissue shadow was seen in the left hilus and expansile pulsations were demonstrated. The mass was attributed to the left pulmonary artery.

Bi-axial kymography (Fig. 3, *C* and *D*): this examination was performed principally for demonstration purposes. There were expansile pulsations of arterial type on the superior and lateral margins of the left hilar mass. *Diagnosis:* prominent left pulmonary artery. *Course:* prostatic resection was performed for benign hypertrophy of the prostatic gland; the postoperative course was uneventful. The patient's general health has been good.

Case iv. J. L., a sixty-five year old male, was admitted to our hospital January 30, 1952. *Chief complaint:* pain and tenderness over lower thoracic spine. *Present illness:* the above symptoms had existed for four months and were accompanied by weight loss of ten pounds during this time. *History:* non-contributory. *Physical examination:* blood pressure was 128/80; pulse rate 76 per minute; pulse rhythm regular. Mediastinum was widened to percussion. *Laboratory data:* the electrocardiogram was within normal limits. The bone marrow smear revealed no evidence of myeloma. Serology was positive. *Roentgen examination* (Fig. 4, *A* and *B*): the significant finding was an apparent fusiform aneurysm of the descending limb of the aortic arch.

Bi-axial kymography (Fig. 4, *C* and *D*): this examination revealed that the fusiform mass pulsated along its superior and lateral margins with arterial wave forms. *Diagnosis:* aortic aneurysm. *Course:* surgical wrapping of the aortic aneurysm was tried but abandoned.

Case v. W.C., a sixty-seven year old male, was admitted to our hospital October 16, 1951. *Chief complaint:* "fainting spells." *History:* there had been episodes of syncope for two weeks and a moderate but indeterminate weight loss for about two months. The history was not otherwise relevant. *Physical examination:* blood pressure 160/105; pulse rate 80 and regular. There was bilateral cervical lymphadenopathy with small, firm nodes palpable. An epigastric mass was found. It was fixed to the deep tissues and was apparently nodular and non-pulsatile. *Laboratory data:* blood sugar was normal. The serology was negative. The cerebrospinal fluid displayed normal dynamics, a negative Kolmer but a 55554320 Lange curve. *Roentgenologic examination* (Fig. 5, *A* and *B*): (1) There was a left paramedian mass with film and fluoroscopic characteristics of the aorta. (2) There was a right hilar mass which was discrete and displayed slight pulsations, apparently transmitted. It measured 3.5 cm. in diameter. (3) A smaller right paratracheal mass was attributed to an enlarged lymph node.

Bi-axial kymography (Fig. 5, *C* and *D*): this examination was performed to confirm the transmitted character of the right hilar mass pulsations. The films displayed aortic pulsations of the left paramedian mass. The right hilar mass disclosed slight blunted waves laterally, but none horizontally on its superior or inferior surface. *Diagnosis:* malignant neoplasm, right para-hilar. *Course:* biopsy of a cervical lymph node revealed anaplastic carcinoma. The patient died at home on May 10, 1952.

Case vi. J.W.J., a forty-eight year old male, was admitted to our hospital November 1, 1951. *Chief complaint:* bloody sputum. *Present illness:* patient had had hemoptysis for three months in varying quantity up to a teaspoonful. There had been intermittent jaundice, right upper quadrant abdominal pain, anorexia and weakness. *Past history and family history:* not contributory. *Physical examination:* the initial examination revealed the presence of hepatomegaly and ascites, without significant chest findings. *Laboratory data:* serology was positive. There was a moderate leukocytosis. A liver biopsy was reported "indeterminate." *Roentgen examination* (Fig. 6, *A* and *B*): there was a left hilar mass with discrete convex outer border; it was slightly pulsatile but the type of pulsation was not definite. The mass was not separable fluoroscopically from the great vessels. The left lung field was hyper-radiant with a paucity of vascular shadows. The left hemidiaphragm was slightly elevated.

Bi-axial kymography (Fig. 6, *C* and *D*): there were pulsations along the superior and lateral margins of the mass; the waves were blunted suggesting a thrombosed aneurysm of the pulmonary artery or possibly of the sinus of the Valsalva. The likelihood of malignancy was, of course, considered strongly in the light

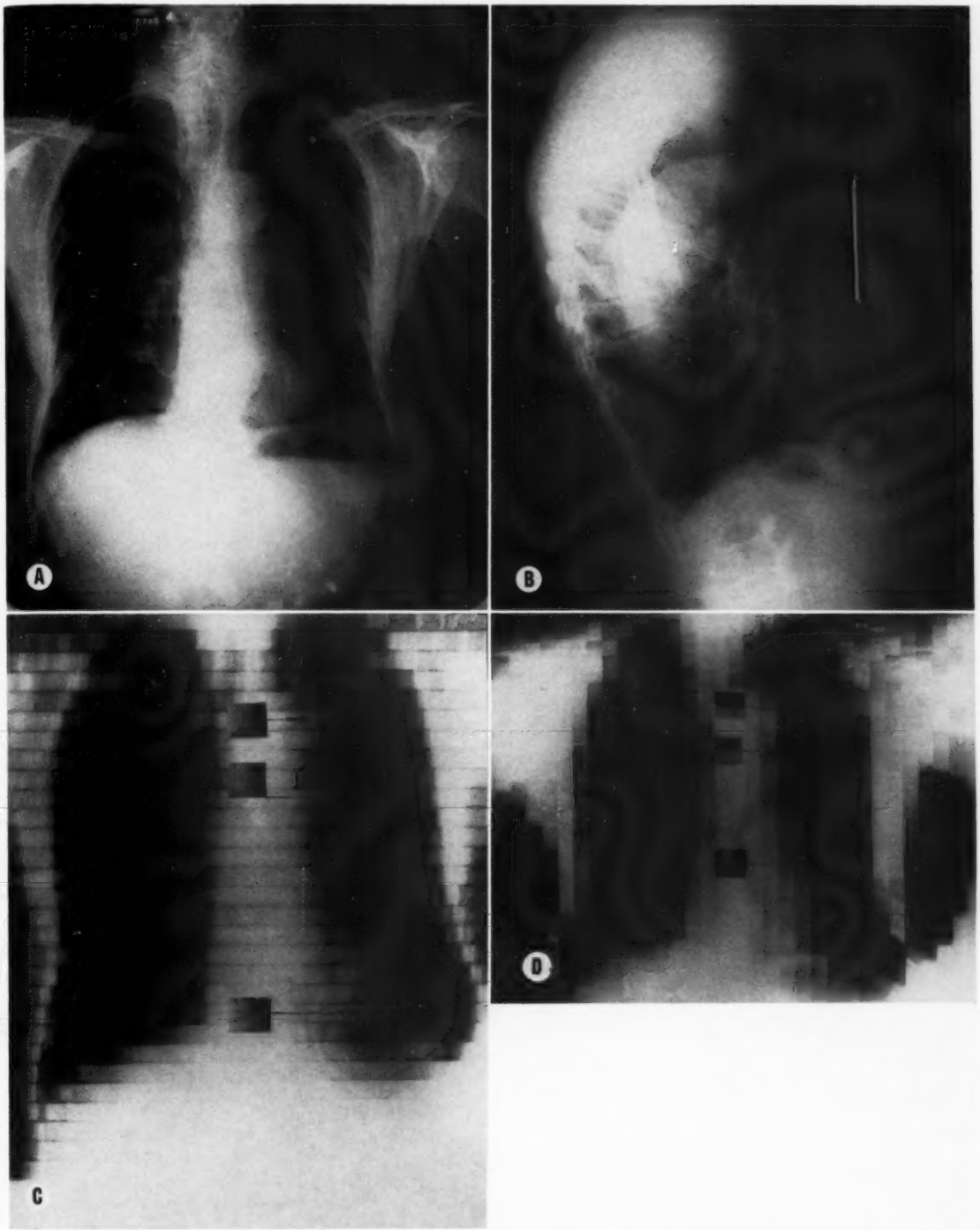

Fig. 4. Case iv. J.L. (*A* and *B*) Posteroanterior and lateral films show a left posterior mediastinal mass which appears continuous with the descending aorta. Fluoroscopy revealed apparent expansile aortic pulsations of the mass. (*C* and *D*) Bi-axial kymograms confirm aortic-type waves on the superior and lateral aspects of the mass. Upper and lower arrows, aortic arch and left ventricle. Middle arrow, mediastinal mass (aortic aneurysm). Insets magnified 2×.

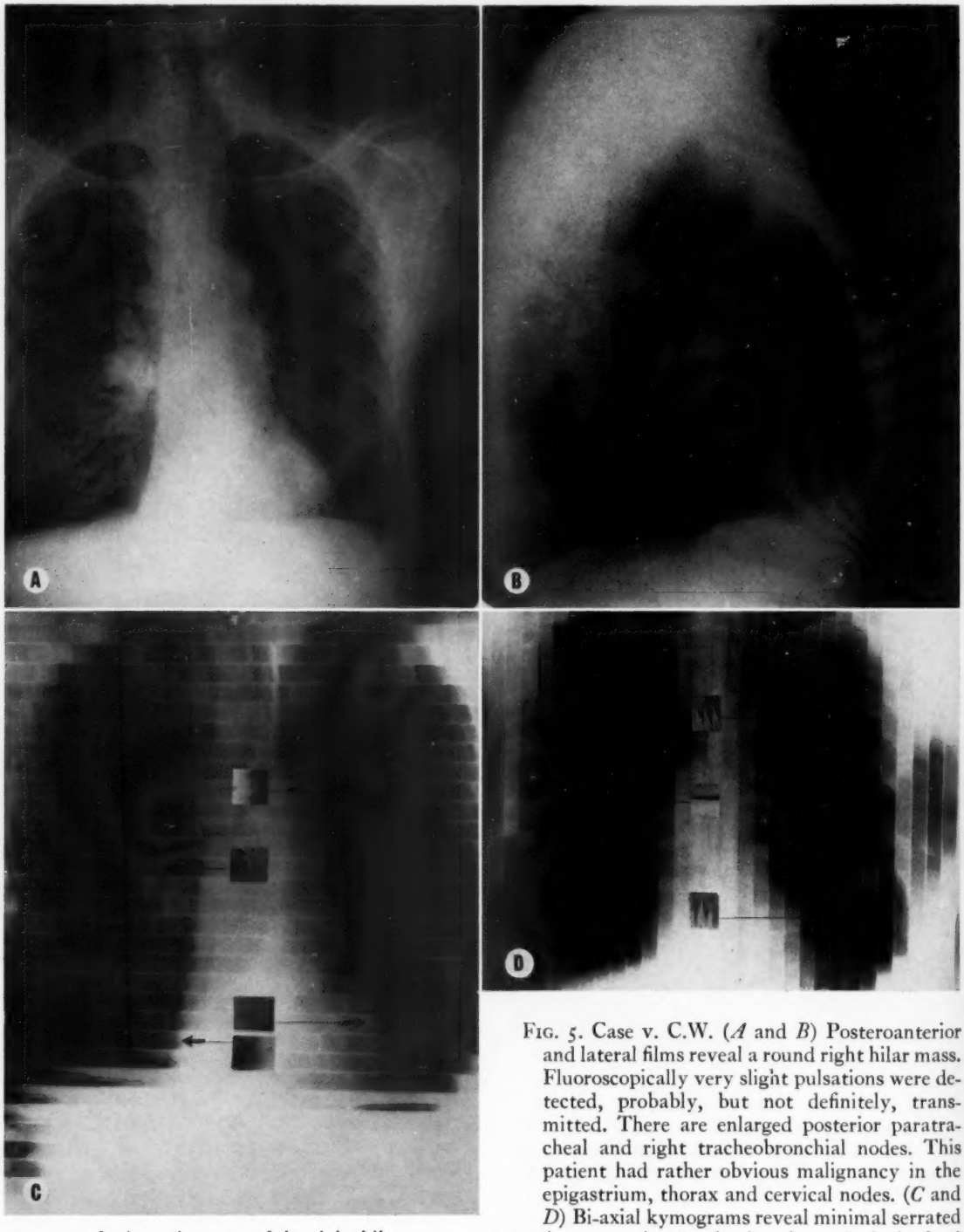

Fig. 5. Case v. C.W. (*A* and *B*) Posteroanterior and lateral films reveal a round right hilar mass. Fluoroscopically very slight pulsations were detected, probably, but not definitely, transmitted. There are enlarged posterior paratracheal and right tracheobronchial nodes. This patient had rather obvious malignancy in the epigastrium, thorax and cervical nodes. (*C* and *D*) Bi-axial kymograms reveal minimal serrated waves on the lateral aspect of the right hilar mass, representing transmitted pulsations in a relatively fixed mass. Superiorly, there are no waves. Upper arrow, aorta. Lower two arrows, left ventricle and right auricle. Middle arrow, right hilar mass. Insets magnified 2×, partly retouched.

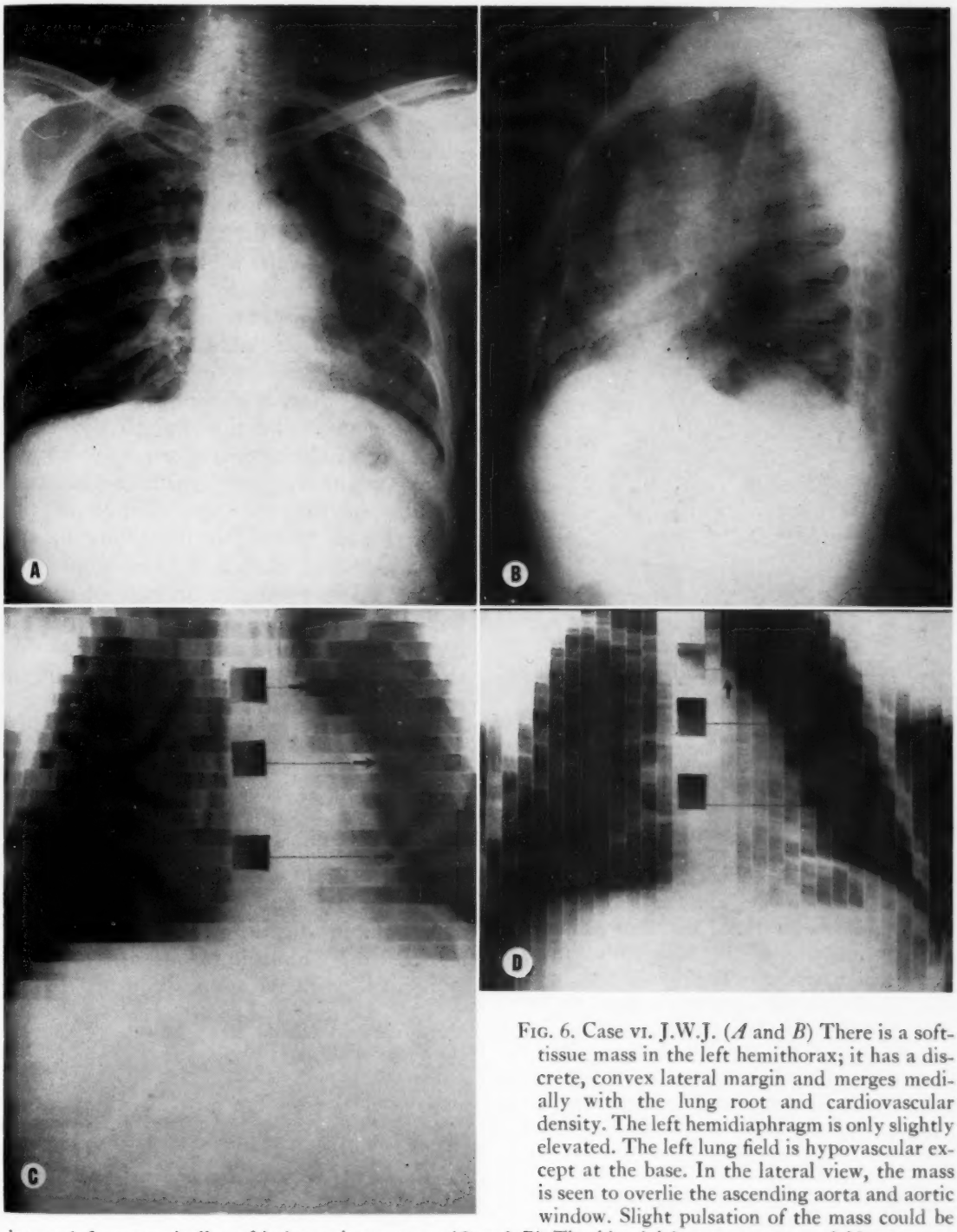

FIG. 6. Case VI. J.W.J. (*A* and *B*) There is a soft-tissue mass in the left hemithorax; it has a discrete, convex lateral margin and merges medially with the lung root and cardiovascular density. The left hemidiaphragm is only slightly elevated. The left lung field is hypovascular except at the base. In the lateral view, the mass is seen to overlie the ascending aorta and aortic window. Slight pulsation of the mass could be detected fluoroscopically, of indeterminate type. (*C* and *D*) The bi-axial kymograms reveal blunt waveforms along the lateral and superior margins of the mass, indicating expansile pulsations.

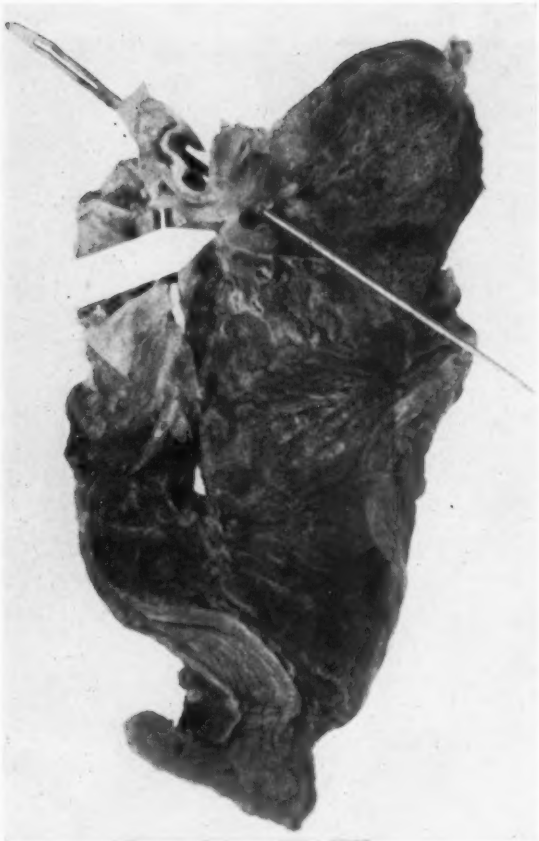

Fig. 7. Case vi. J.W.J. Postmortem demonstration of the left lung, sectioned longitudinally. The neoplasm (white arrow) surrounds the bronchus and artery to the left upper lobe, which is almost completely atelectatic.

of the history, the physical findings, and roentgen examination by films and fluoroscopy. *Angiocardiograms:* failed to show filling by contrast medium of the mass or of the left upper lobe vascular tree. *Bronchoscopy:* a mass was found to invade the left upper lobe bronchus; biopsy diagnosis was "atypical cells, malignant." *Ascitic fluid smear:* revealed malignant cells. *Course:* the patient died subsequently. Autopsy revealed a metastatic hepatoma at the left lung root occluding the left upper lobe bronchus (Fig. 7).

Comment. This case was instructive in that bi-axial kymography failed to establish the diagnosis in the presence of a solid mass at the left lung root and atelectasis of the left upper lobe. We attributed the bi-axial pulsations of the left hilar density to the presence of the atelectatic left upper lobe, whose elasticity reflected the pulsations of the adjacent left pulmonary artery. These pulsations were seen in two axes, probably because of the change in direction of blood flow between the left pulmonary artery (producing the vertical pulsations) and its lower lobe branch (producing the horizontal pulsations). One might also expect the vertical and horizontal pulsations in the case of a cyst immediately adjacent to the heart or great vessels, because the fluid within the cyst would be likely to transmit pulsations radially.

Another possible source of difficulty in differential diagnosis might be a mass pulsating in a direction 90° to the plane of the film; the appearance of the kymograms might suggest expansile pulsation because of the apparent change in the vertical and transverse diameters of the mass. However, the wave forms would not be arterial in type and, in case of doubt, kymography in the lateral position would disclose the forward and backward shift of the mass if the pulsations were transmitted rather than expansile.

SUMMARY

1. A bi-axial kymographic examination has been described as a supplement in the differential diagnosis of thoracic aneurysm and mediastinal solid tumor.

2. Although not infallible, the method offers aid in the differentiation of transmitted from expansile pulsations.

3. Six illustrative cases are presented.

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EFFECT OF CORTISONE ON THE RADIATION REACTION OF THE RAT LUNG

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THE effects of ionizing radiation on the lung have been observed and reported over the past forty years. There is general agreement that the incidence of clinical symptoms and densities on roentgenograms of the chest are variable and unpredictable following roentgen therapy of the lungs. Histologic changes in irradiated lungs depend on the amount of radiation and the length of time between irradiation and examination.

Warren and Spencer[9] reported 234 patients with radiation pneumonitis, who had received roentgen treatment of the lungs, studied at autopsy. Twelve per cent had histologic changes in the lungs interpreted as being caused by irradiation. These changes consisted of alveolar hyaline membrane formation, swelling and destruction of alveolar cells, and marked edema. Late reactions observed were vascular hyalinization and fibrosis and bronchial wall fibrosis. Chest roentgenograms for 62 of the patients were included in the study. Of these, 8 per cent showed changes interpreted as the result of irradiation. The time intervals between roentgen treatments and roentgenographic examination were not stated. Mallory[7] described a relatively pure form of alveolar wall fibrosis in patients who had received large doses of radiation to the lungs.

Huguenin *et al.*[6] described radiation reactions in the lungs of patients after treatment directed to the breast. The roentgen dosage and the number of cases were not stated. The incidence of pulmonary reaction was given as 2.5 to 3.0 per cent. Half of the patients whose roentgenograms showed densities had no symptoms. The roentgenographic changes were described as cloudy opacities, small nodules, large nodules, densities extending over the entire thorax, retraction of the trachea and heart, and tenting of the diaphragm.

These papers illustrate the difficulty of determining the pathogenesis of the radiation reaction of the lung in humans. Frequently dosage is not stated, or it varies within a series of studies. The time interval between irradiation and examination is not uniform. The incidence of changes recognizable clinically ranges between about 3 and 20 per cent. These variables make it necessary to study animals in order to obtain more nearly uniform conditions.

Many animal studies have been made in order to observe the effects of radiation on the lungs under controlled conditions. Bull Englestad[3,4] described studies with rabbits. The major reaction after an epidermicidal dose consisted of degenerative changes in the bronchial epithelium and lung stroma accompanied by inflammatory processes in the peribronchial, perivascular, and alveolar tissues. Warren and Gates,[8] studying rats and rabbits one day to twelve weeks after doses of 1,200 to 5,400 r, concluded that the bronchial epithelium was relatively stable in contrast to the alveoli. There was a striking increase in the fibrous tissue of the septa and around the bronchi and blood vessels.

The reaction of the lung might be modified by pharmacological agents directed at reducing secondary infection or inhibiting inflammatory response. One of the agents that could affect the changes following irradiation is cortisone. Cortisone in large doses has been reported (1) to inhibit fibroblastic activity in tissue culture, (2) to cause disintegration of the reticular net-

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work, (3) to interfere with phagocytic capacity of the reticuloendothelial system, (4) to delay wound healing, (5) to depress protein synthesis, and (6) to inhibit experimental adhesions. However, at clinical levels of cortisone dosage these large doses are seldom used, and an anti-inflammatory effect is the common observation.

Cosgriff and Kligerman[2] reported subjective improvement in one patient with post-irradiation acute pulmonary reaction treated with cortisone. Irradiation changes of atelectasis and fibrosis appeared two months after the discontinuance of cortisone. Friedenberg and Rubenfeld[5] reported 10 cases treated with cortisone, starting one week after the beginning of roentgen therapy. Patients were followed for one to thirteen months. No fibrosis was observed in the zone of irradiation. Bluestein and Roemer[1] reported one patient with cough, dyspnea, and linear densities in both lung fields after treatment with radiation passing through both normal lungs directed to a skin nodule. This patient was treated with cortisone, and three months after the beginning of therapy the patient was without symptoms and the chest film was considered to be normal.

In order to evaluate the effect of cortisone on the radiation reaction of the lung, the following conditions should be established: (1) The roentgen dose should be known and should be uniform. (2) The incidence of clinically evident pulmonary reaction should be predictable. (3) The mortality of animals should be low during the period of observation. It was believed that an investigation meeting these conditions would contribute information on the pathogenesis of the radiation reaction and that, when the pulmonary reaction could be predicted, agents such as cortisone and/or antibiotics could be introduced to determine whether or not there was any observable change in the reaction of the lung under the conditions of the experiment.

In the present investigation, the reaction of the rat lung to a sublethal dose of roentgen rays was studied in repeated experiments under uniform conditions. The series of observations in these studies included mortality, weight changes, serial roentgenographic studies of the thorax, and, at the end of an observation period of ninety days, bronchograms, arteriograms, venograms, and macroscopic and microscopic examination of the lungs. The same series of observations was employed to investigate the effects of cortisone and terramycin on the clinical course of the animals and on the extent of pulmonary damage.

METHODS

Animals. Fischer line 344 rats were used in the first and fourth experiments. In the second and third experiments, the rats were the F_1 generation from the cross Fischer line 344 females$\times$(A$\times$C) line 9,935 males, referred to as FAC-F_1. In all experiments except the second the rats were randomized as to sex, age, and weight. In the second experiment there was no special randomization as to sex. The rats were housed in drawer-type cages with wire mesh floors 130 cm.^{2} in area, 1 rat per cage. They were constantly supplied with Purina Laboratory Chow Checkers and water *ad lib.* The average daily intake of water per rat was about 20 to 30 cc.

Radiation Factors. The radiation source was a 250 kv. constant potential unit with no added filtration. The half-value layer was 0.47 mm. Cu. The target-animal distance was 70 cm. Measurements were made with a Victoreen thimble chamber in the hemithorax field instead of a rat and with the lead shielding in place. The field size was approximately 2$\times$4 cm. The dose rate was approximately 125 r/min.

Exposure of Animals. Prior to exposure the rats were anesthetized with sodium pentobarbital (4.5 mg./kg.). During irradiation each rat was completely shielded with the exception of the right hemithorax, the area irradiated. The dose measured under the lead shielding was less than 1 per cent of the total amount administered to the exposed field.

Experimental Groups:

Experiment 1. In this preliminary experiment, four groups of 3 animals each were given doses ranging from 2,000 to 4,200 r. The dose was administered to the right hemithorax in a single exposure.

At 2,000 and 3,000 r, no deaths occurred. At 3,600 r, 1 death occurred on *day 44* after irradiation; at 4,200 r, all 3 animals of a group of three died (*days 15*, *25*, and *65* after irradiation).

From these results it was concluded that the highest dose which would permit 100 per cent survival over a ninety-day observation period with reasonable certainty was about 3,000 r. In addition, at doses of 3,000 r and higher, roentgenograms taken sixty days after irradiation uniformly showed complete atelectasis of the irradiated lung, suggesting that at 3,000 r this observation could be employed in evaluating the effects of drugs on the pulmonary reaction.

On the basis of this experiment, 3,000 r was selected as the dose to be administered in the subsequent experiments. It was considered to be a sufficiently large but sublethal dose, which would permit observation of the clinical course of most of the animals over a period of ninety days.

Experiment 2. A total of 41 rats was divided into the following major groups: (1) general (non-irradiated) controls, subjected only to periodic handling; (2) irradiated controls receiving no other treatment; (3) animals receiving irradiation plus drug treatment for ninety days. The animals in the latter group were divided into three drug-treatment groups: cortisone, terramycin, and cortisone plus terramycin. These were further divided into subgroups according to the time drug treatment was started: *day 3* prior to irradiation (*day 0−3*), *day 14* after irradiation (*day 0+14*), and *day 28* after irradiation (*day 0+28*). There were also two drug control groups receiving no irradiation: cortisone, and cortisone plus terramycin, with treatment starting on *day 0 −3*.

Cortisone acetate* was administered by subcutaneous injection (2 mg. daily). Terramycin HCl was given in the animal's drinking water (concentration, 1 mg./cc.) and the daily intake of water per rat was 20 to 30 cc. Bacteriological tests showed that there was no significant deterioration of bacteriostatic activity in the twenty-four hours between changing of drinking water.

All irradiated animals were given 3,000 r to the right hemithorax in a single exposure.

Experiments 3 and 4. These experiments were concurrent and identical with the exception of employing different strains of rats—hybrid FAC-F_1 in the third and Fischer line 344 in the fourth experiment.

A total of 48 animals was divided into the same three treatment groups described for Experiment 2: cortisone, terramycin, and cortisone plus terramycin. However, only one treatment period was used, starting on *day 0−3* and continuing for ninety-three days. The same general controls and the same drug controls were employed.

Clinical Course of Animals. During the ninety-day period after irradiation the animals were observed daily and notes were made regarding their general appearance, skin reaction, nasal discharge, and food and water intake. They were weighed weekly. Thoracic roentgenograms were taken at two- or three-week intervals. The deaths that occurred during this period were due to respiratory disease. Autopsy showed bilateral pneumonia, sometimes with massive pleural effusions. At the end of the observation period, all surviving animals were sacrificed by ether inhalation.

RESULTS

MORTALITY

In Experiment 1, all animals receiving 3,000 r survived, whereas in Experiment 2 all irradiated controls receiving the same dose died.

In Experiment 2 (Table 1), the data indicate that cortisone reduced mortality and that the best time to administer the drug

* Cortisone acetate for all experiments was supplied through the courtesy of Merck and Co., Medical Research Department.

TABLE I

MORTALITY, EXPERIMENTS 2–4

Day Drug Treatment Started	Deaths			Deaths (Total)	Total No. in Group
	Days				
	0–29	30–59	60–89		
EXPERIMENT 2					
Controls: Non-irridiated	0	1	0	1	4
Irradiated	1	1	1	3	3
Groups Treated with Cortisone					
Controls (Day 0 −3)	0	0	0	0	3
Day 0 −3	1	1	1	3	5
Day 0 +14	2	2	1	5	5
Day 0 +28	0	1	2	3	5
Total	3	4	4	11	15
Groups Treated with Terramycin					
Day 0 −3	0	1	3	4	4
Day 0 +14	1	2	1	4	4
Total	1	3	4	8	8
Groups Treated with Cortisone Plus Terramycin					
Controls (Day 0 −3)	0	0	0	0	3
Day 0 −3	0	0	0	0	3
Day 0 +14	0	1	0	1	4
Day 0 +28	0	1	2	3	4
Total	0	2	2	4	11
Cortisone Treated					
Combined Treatment Groups (Day 0 −3, day 0 +14, and day 0 +28)	3	6	6	15	26
No Cortisone					
	2	4	5	11	11
EXPERIMENTS 3 AND 4					
Cortisone Treated					
Combined Treatment Groups (Day 0 −3)	1	3	3	7	25
No Cortisone					
	2	4	3	9	23

was prior to irradiation (*day 0−3*). The administration of terramycin alone did not increase survival. The effect of cortisone is more readily seen when the data are rearranged into two groups: (1) the total number of animals receiving cortisone treatment, both alone and in combination with terramycin; (2) the total number of animals not treated with cortisone, including the irradiated controls plus the animals treated with terramycin alone. (See Table 1, *Combined Treatment Groups.*)

The same comparison of mortality for combined treatment groups in Experiments

3 and 4 (Table I), however, did not confirm the increased survival of cortisone-treated animals found in Experiment 2. When all of the mortality data of all experiments are reviewed, it would appear that survival was not significantly increased or decreased in cortisone-treated animals.

WEIGHT CHANGE

In all experiments, the body weight of each animal was determined at weekly intervals during the ninety-day observation period after irradiation and was plotted as a percentage of initial body weight. Composite weight curves for each treatment and control group were also compared.

The weight of all irradiated rats, both drug treated and not drug treated, decreased approximately 10 per cent during the first week after irradiation.

Non-Survivors. Two characteristic patterns of weight change were observed: (1) a steady decline in weight beginning after *day 0* and continuing until death, and (2) partial recovery from the initial weight loss of the first week followed by a second period of decline starting on *day 20* to *day 30* and continuing until death. Nearly all of these animals' roentgenograms showed densities which developed sometime after *day 21*.

Survivors. In these animals there was a gradual recovery from the weight loss of the first week after irradiation. In irradiated animals whose roentgenograms showed no densities (cortisone-treated animals), weight at ninety days after irradiation ranged from 95 to 105 per cent of initial body weight as compared with 115 to 120 per cent in non-irradiated controls. In irradiated animals whose roentgenograms showed densities, weight at ninety days varied and was correlated with the degree of involvement indicated by the roentgenograms. In this group, many animals with complete atelectasis or with bilateral densities, sacrificed at ninety days, probably would have died if the period of observation had been prolonged two to three weeks.

The non-irradiated control animals treated with cortisone showed no gain in weight or gains up to only 105 per cent of their initial body weight as compared with 115 to 120 per cent in the non-irradiated, non-cortisone treated controls. There was an increase in weight within two weeks after cortisone was stopped at the end of ninety days so that the total body weight approached that of the controls not given cortisone. This, presumably, was evidence of the catabolic action of cortisone, and could represent an undesirable side effect.

In Experiment 2, the weight curves for the irradiated, cortisone-treated groups as a whole showed better weight gain following the initial weight loss than did the curves for the irradiated, non-cortisone treated groups. In the third and fourth experiments, this trend was not evident for the cortisone-treated groups as a whole but was apparent only as related to the clinical course of individual animals.

ROENTGENOGRAPHIC EXAMINATION

Serial Thoracic Roentgenograms. The results of these studies for Experiments 2–4 are shown in Table II, where densities are tabulated as either partial or complete. Figures 1 and 2 are examples of roentgenograms showing the author's interpretation of partial and complete right lung densities, respectively.

Because deaths occurred throughout the ninety-day observation period, the number of animals alive at the time of roentgenographic examination (ten, thirty, sixty, and ninety days after irradiation) is also shown in Table II in order that incidence of densities in survivors might be determined.

If all the data of Experiments 2, 3, and 4 are examined, it is apparent that the incidence and degree of density were similar in the cortisone- and non-cortisone-treated animals for the first thirty days after irradiation. At sixty days, the incidence of complete collapse of the right lung was greater in the animals not treated with cortisone, and this was still true at ninety days. At this time 12 of the cortisone-treated animals had roentgenograms with

TABLE II

INCIDENCE OF DENSITY IN SERIAL THORACIC ROENTGENOGRAMS

Drug Treatment and Day Treatment Started	Days After Irradiation											
	10			30			60			90		
	Density Incidence (Survivors) on Roentgenograms											
	Alive	Partial	Complete	Alive	Partial	Complete	Alive	Partial	Complete	Alive	Partial	Complete
EXPERIMENT 2												
Non-Irradiated Controls												
No drugs	4	0	0	4	0	0	4	0	0	4	0	0
Cortisone (Day 0 −3)	4	0	0	4	0	0	4	0	0	4	0	0
Terramycin (Day 0 −3)	4	0	0	4	0	0	4	0	0	4	0	0
Irradiated Groups												
Cortisone:												
Day 0 −3	5	0	0	4	2	0	3	2	0	2	0	2
Day 0 +14	5	0	0	3	1	0	1	1	0	0	—	—
Day 0 +28	5	0	0	5	2	0	3	2	0	2	1	0
Cortisone+Terramycin:												
Day 0 −3	3	0	0	3	1	0	3	0	0	3	0	0
Day 0 +14	4	0	0	3	2	1	3	2	0	3	1	0
Day 0 +28	4	0	0	4	3	0	3	3	0	1	1	0
Terramycin:												
Day 0 −3	4	0	0	4	1	1	3	1	2	0	—	—
Day 0 +14	4	0	0	3	0	0	1	0	1	0	—	—
No Drugs	3	0	0	2	1	0	1	0	1	0	—	—
EXPERIMENTS 3 AND 4												
Non-Irradiated Controls												
No Drugs	7	0	0	7	0	0	7	0	0	7	0	0
Cortisone+Terramycin	7	0	0	7	0	0	7	0	0	7	0	0
Irradiated Groups												
Cortisone (Day 0 −3)	10	0	0	10	3	0	9	5	1	7	3	2
Cortisone+Terramycin (Day 0 −3)	14	0	0	14	4	0	14	6	3	12	5	3
Terramycin (Day 0 −3)	14	2	0	13	5	1	11	6	5	10	4	6
No Drugs	7	1	0	6	2	1	5	1	4	4	0	4

no densities compared with no animals in the non-cortisone treated groups. In the former there was also a larger number whose films showed only partial lung densities and a smaller number whose films showed complete lung densities compared with the latter group.

Bronchograms and Arteriograms. At the end of the ninety day observation period additional studies were made of 10 surviving animals. These employed bronchograms and pulmonary arteriograms for which lipiodol and diodrast, respectively, were the opaque media used. Two of the bronchograms are shown in Figures 3 and 4. These illustrate typical examples of obstruction close to the carina, one of the reasons for collapse of the lung, the most common of the sequelae of this amount of radiation.

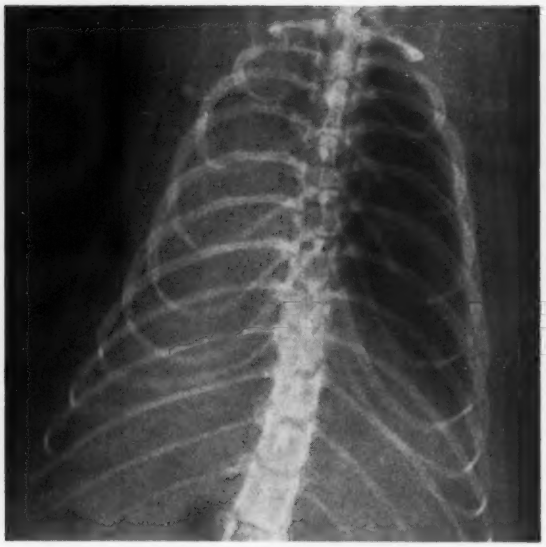

Fig. 1. Complete atelectasis, right lung.

Pulmonary arteriograms of collapsed lungs showed the large arteries patent. Further interpretation was not possible because of lack of information concerning the vascular pattern in collapsed lungs.

PATHOLOGIC STUDIES

Ninety days after irradiation the surviving animals were sacrificed and were examined grossly and microscopically with serial sections through both lungs.

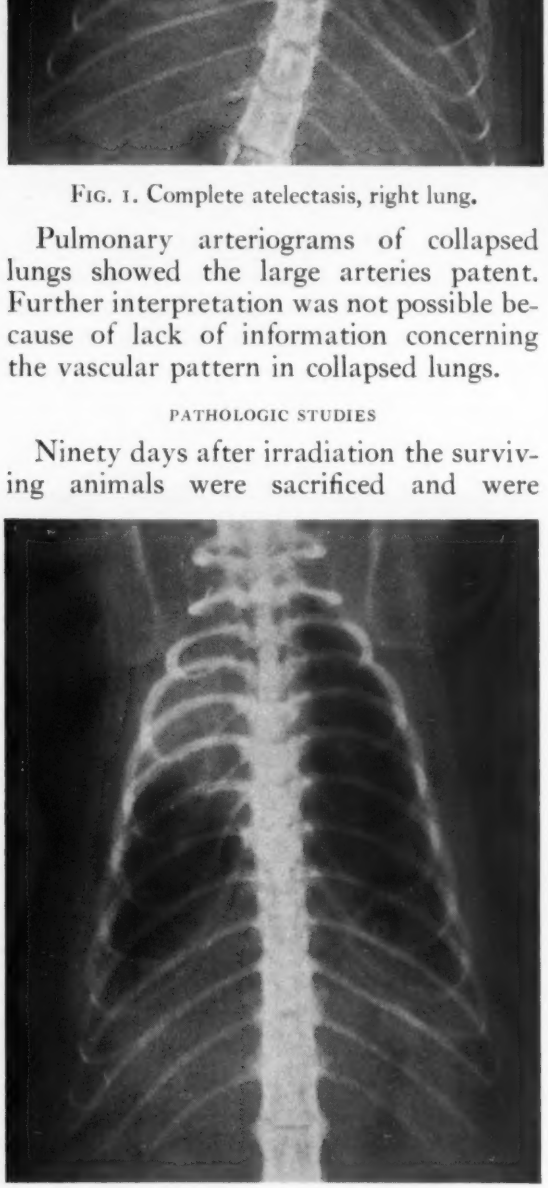

Fig. 2. Partial atelectasis, right lung.

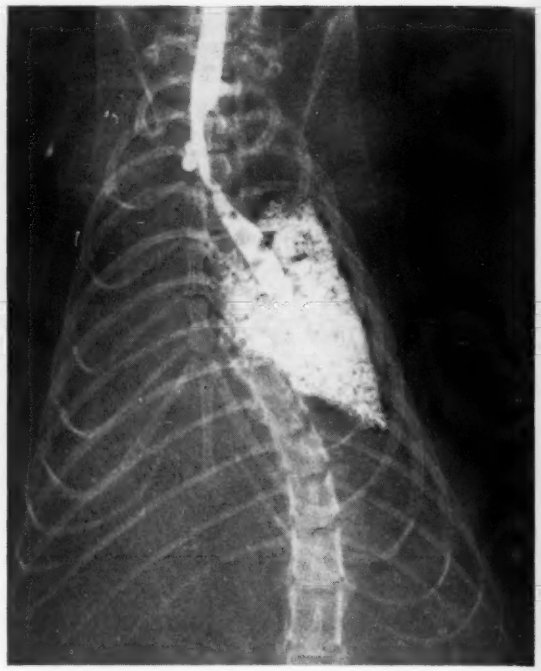

Fig. 3. Bronchogram showing narrowing of the trachea and obstruction of the right main stem bronchus. Narrowing of the left main stem bronchus is present as a result of accidental extension of the field of radiation past the midline of the animal.

Macroscopic Examination. The appearance of each irradiated right lung that had collapsed completely was similar for all treatment groups. The collapsed right lung was smaller in size than the non-irradiated left lung, the mediastinum had shifted to the right, and compensatory left lung emphysema was found.

The appearance of each irradiated right lung that had not collapsed was similar to that of the non-irradiated lung. This observation emphasized the importance of collapse on the subsequent changes in the lung. When aeration had been maintained, the effect of the roentgen dose was not macroscopically apparent ninety days after irradiation.

Microscopic Examination:

Animals with Atelectasis. Proliferation and hypertrophy of the bronchial epithe-

lium were frequently present. No difference could be detected between the appearance of the epithelium of animals treated with cortisone and that of animals not treated with cortisone.

Squamous metaplasia of the bronchial and tracheal epithelium was frequently found. Its incidence was not affected by cortisone administration. Metaplasia was usually accompanied by inflammatory cell exudation and abscess formation, indicating that infection was often associated with this cellular change. It was noted in some instances that the margins of the squamous metaplasia very closely approximated the field of radiation, as illustrated in the section through the carina shown in Figure 5. The metaplasia circles the bronchus with such a sharply demarcated border that it definitely suggests a primary radiation effect rather than a secondary effect caused by impaired blood supply, since impairment of blood supply could be expected to cause an uneven extension of the margins of the metaplasia.

Peribronchial fibrosis was observed in all animals with collapsed lungs. The degree of fibrosis was graded on a scale of 1+ to 4+ without knowledge of the drug treatment the animal had received. The results showed that the animals which had been irradiated and not given drugs, or those irradiated and given terramycin, had been graded 2+ to 4+. Irradiated animals given cortisone, or cortisone plus terramycin, had been graded 1+ to 3+. Thus, the effect of cortisone could be identified in some instances even in the presence of atelectasis. However, this effect was not marked and perhaps was not significant.

There was little evidence of any pronounced changes resulting from irradiation in the alveolar cells. It is possible, however, that atelectasis may have obscured such changes. No hyaline membranes were observed in any of the irradiated lungs. Intra-alveolar exudates were found in some. The drug treatment did not noticeably affect the incidence of such exudates.

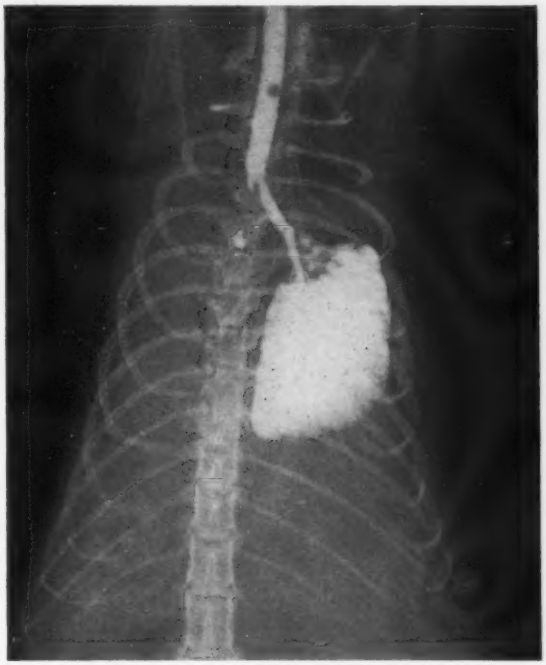

Fig. 4. Bronchogram showing obstruction of the right main stem bronchus. There is a possibility that obstruction may be localized to the region seen since there is a collection of lipiodol distal to the narrowed segment.

Changes in the blood vessels such as intimal and medial thickening, perivascular fibrosis, and capillary obliteration were observed, but they were not nearly as prominent as the changes involving the bronchi.

Animals without Atelectasis. In lungs that had not collapsed the bronchial epithelium was flat. The bronchial villi were not present, and there was little, if any, increased peribronchial fibrosis. The alveolar cells were thin and flat, with no evidence of infection or exudate. Vascularity appeared intact. In some instances, as shown in Figure 6, it was difficult to detect any difference between the irradiated right lung and the non-irradiated left lung. In other instances, the changes described above were sufficiently marked to permit identification of the irradiated right lung.

Comment on the Pathology. Microscopic examination of the lungs of all surviving animals, with and without atelectasis, showed the decisive factor in producing

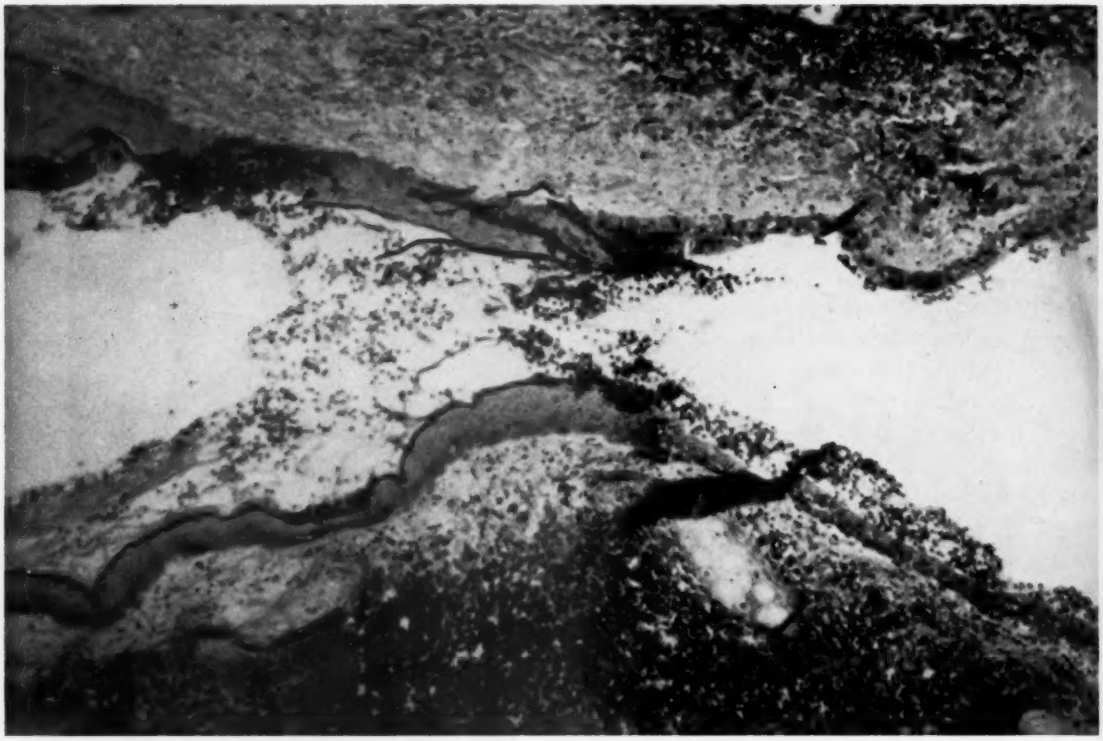

Fig. 5. Cross section through the carina showing squamous metaplasia sharply demarcated at the margin of the roentgen-ray field. Masson stain. ×50.

increased fibrosis to be the occurrence of atelectasis. Collapse of the lung was dependent upon the degree of bronchial obstruction, and obstruction was due to epithelial proliferation, edema, inflammation, exudation, desquamation, and infection, with subsequent fibrosis as a reparative response to these degenerative changes.

Cortisone administration may have had the effect of suppressing the degree of this reaction, in some instances enough to maintain aeration. When the degree of bronchial reaction resulted in bronchial obstruction and collapse of the lung, the administration of cortisone and/or terramycin was not effective in reversing or greatly altering the ensuing infection, necrosis, and fibrosis.

Because of the difference in size of the major bronchi in rats and in man, the same results might not be applicable to the latter. It is of interest to note, however, that Cosgriff and Kligerman[2] reported that radiation over the human hilus produced a higher incidence of fibrosis than radiation over the parenchyma.

DISCUSSION

On the basis of mortality in the first experiment, 3,000 r was selected as the roentgen dose which, delivered to the right lung in one exposure, would produce an effect of sufficient severity and uniformity to be observed roentgenographically and would allow survival over a period of ninety days. Although this dose produced sufficient uniformity of effect in the second, third, and fourth experiments, as shown by the roentgenograms, there was a high mortality within the ninety-day period. This added an undesirable variable in these experiments and reduced the number of experimental animals. Death during this period was due to pneumonia, which usually affected both lungs. Roentgenograms taken near the time of death showed that both lungs had partial or complete densities.

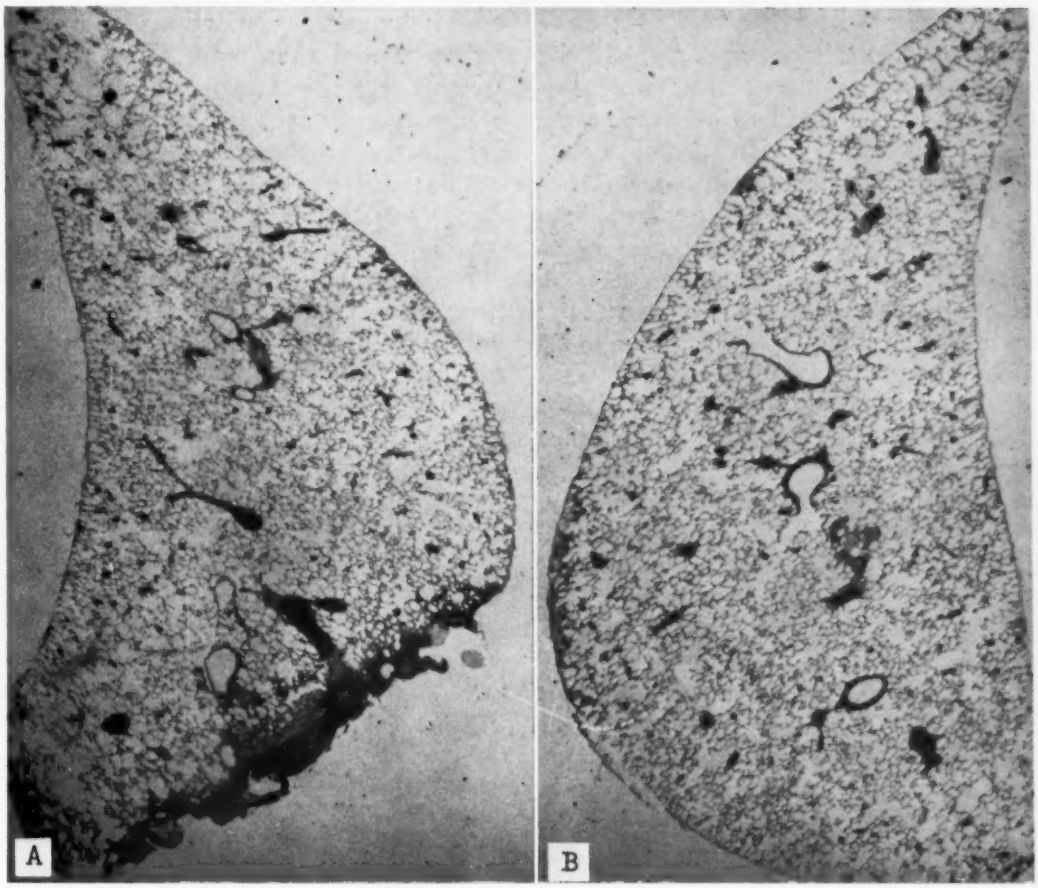

Fig. 6. Longitudinal sections of the right and left lungs of a cortisone-treated animal without atelectasis. The irradiated right lung (*A*), except for slight, generalized atrophy, is similar to the unirradiated left lung (*B*). Masson stain. ×8.

Terramycin did not increase survival nor did it reverse pneumonia after it had been observed roentgenographically. Cortisone alone or in combination with terramycin neither increased nor decreased survival significantly.

In some animals cortisone treatment gave remarkable protection from the development of atelectasis. The mechanism of protection was not determined, but the pathologic studies suggested that, by cortisone's inhibition of acute inflammatory processes, aeration of the lung was maintained. In animals with unimpaired aeration the primary effect of the radiation (cell damage leading to atrophy) was not overshadowed by the complications following bronchial obstruction. This was demonstrable in the microscopic sections in that no increase in fibrosis was found in any sections of a lung that had retained completely its function of aeration. Thus, the fibrosis observed in the collapsed lung would appear to be part of a complex reaction rather than a selective response of fibrous tissue to radiation. Whether or not physiologic function of the lung in these cortisone-treated animals would have continued after an additional time-interval would require further study.

Varying roentgen dosage, in particular, needs further investigation. A dose of 3,000 r in one exposure to an entire rat lung is a larger biologically equivalent dose than that usually delivered in fractionated therapeutic irradiation of the human lung.

Lower doses might make the protective effect of cortisone more apparent. If the total reaction to a lower dose were less severe and if the effect of cortisone were to reduce this total reaction in some degree, the chance of maintaining physiologic function of the lung would be increased. The effect of fractionation of dose likewise is important and needs evaluation.

Comparison of the results with the bronchograms and other tests demonstrated the importance of using several kinds of observation. The proximal site of obstruction was not apparent from either the serial thoracic roentgenograms or from the postmortem pathologic studies. The disclosure of local constriction in the main bronchus by means of bronchograms was unexpected. It explained, however, why the pattern of atelectasis was so uniform, since closure of the main stem bronchus results in collapse of the entire lung. The relatively small size of the bronchi would seem to be important, but it does not explain why the main bronchial opening is so susceptible to narrowing—unless it has to do with the tracheal reaction in narrowing the bronchial opening owing to edema of the tracheal wall.

SUMMARY

The effect of cortisone on the radiation reaction of the rat was studied during a ninety-day period after irradiation (3,000 r to the right lung in one exposure) by means of mortality, body-weight changes, serial roentgenograms of the lungs, and postmortem macroscopic and microscopic examinations of the lungs.

Cortisone did not significantly increase or decrease survival.

Cortisone was not uniformly effective in preventing atelectasis and fibrosis, but it did completely protect some animals from atelectasis, whereas atelectasis occurred in all animals not given cortisone.

Cortisone may have prevented atelectasis in some animals by inhibiting the general inflammatory reaction following irradiation and thus maintaining aeration. When, with this treatment, the function of aeration was maintained, histologic examination of the lung ninety days after irradiation showed mild, generalized atrophy of all cellular elements, but no increased fibrosis.

In irradiated animals with atelectasis there was increased fibrous tissue around bronchi and blood vessels, whether or not cortisone had been administered. This suggests that bronchial obstruction is important in the pathogenesis of radiation penumonitis, and measures to prevent its occurrence are indicated.

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Thirty-eighth Annual Meeting: Shamrock Hotel, Houston, Texas, April 9–11, 1956.

EDITORIALS

THE RELATION OF THORACIC SURGERY TO ROENTGENOLOGY

IT WAS the beginning of the year 1890. The century was dying. It had been a notable one in medicine. The basic sciences of bacteriology and pathology had been born. The groundwork for modern aseptic surgery had been laid. Anesthesia had been discovered.

The last decade was to give rise to equally important contributions. Within a year of one another Röntgen was to bring forth the x-ray and Forlanini was to describe pneumothorax as a method of treatment in pulmonary tuberculosis. When it is realized that all early attempts in the field of thoracic surgery were in the treatment of tuberculosis, it may be said that Forlanini, even though an internist, may be thought of as the father of thoracic surgery.

The early attempts in the giving of pneumothorax were done blindly without the benefits of a visual approach. With the discovery of the x-ray and its application to the sick person, a new field of medicine was in the making. The fields of roentgenology and pulmonary disease were to become more closely and have become closely knit.

However, a close liaison was to take years to accomplish. Physicians have always been a proud and jealous group, and at the century's turn this was even more marked. There was a feeling among the early medical specialists that each was the master of the field. A surgeon was not permitted to read his own x-ray films. The surgeon was a jealous man, and the roentgenologist with his new found approaches was equally so. Physicians at that time were stubborn men, hard of body and hard of head. They were proud to the point where they approached the deity. These are facts which some physicians will not admit, but they are true.

Interest was growing in the ability to see rather than feel the inner body. For centuries the physician had been able to detect disease only by the use of palpation, auscultation and visual methods. Now a new door was open, and inner visualization was possible. More accurate means of diagnosis, treatment, and the results of treatment were at hand.

Knowledge of the vast unknown in medicine could not grow, however, until there was a pooling of learning, and this could not come until men in all fields were willing to work together toward a common goal, namely, the ultimate solution of the problems which were vexing to them all.

In order that this be accomplished certain things had to happen. The barriers which separated men in special fields of medicine had to be broken. Such persons had to learn, live and work together. It was to take one and possibly two world wars to demonstrate to doctors that great things come when two or more persons forget themselves, learn to work and live together and pool their knowledge.

The first attempts at lung visualization were poor as we know them today. They were, however, a start, and progress was in the making. Surgery was not ready to approach the problems that were present. Anesthesia was poor, and because of lack of a knowledge of its proper uses and because of little knowledge of fluid balance and replacement, it was most difficult to sustain the patient undergoing surgery.

During the first decade of the twentieth century thoracoplasty had been advocated

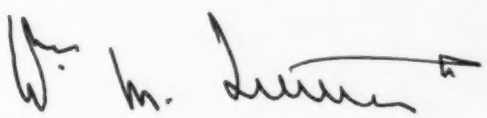
and done. During the second decade sporadic attempts had been made to enter the pleural space. These attempts were made by bold men who now that they were able to see the disease within were willing to attack. The fatality was high because the ground was not ready. Seeing was not enough. The era of accomplishment in the diagnosis of chest disease had to await the surgeon's ability to sustain the patient and his willingness to cooperate in all details with the roentgenologist.

The third decade of the twentieth century was in the making. Evarts Graham became Professor of Surgery at Washington University. He was interested in the surgery of the chest. From feeble beginnings a Chest Service was established. When the Mallinckrodt Institute was founded, the Chest Service was established next door and in direct communication with the X-ray Department. This I feel was one of the earliest attempts to attack these problems on a common ground. Such problems were studied in complete cooperation by both departments. Much was learned in those early days which could not otherwise have been acquired. It was the true beginning of the realization that complete cooperation must exist between the roentgenologist, the internist and the thoracic surgeon in order that the work of all may be the best.

The thoracic surgeon must learn to read well the roentgenograms of his patients. He must do this for two reasons. It is impossible for a surgeon to talk and work intelligently with the roentgenologist unless he too knows whereof he speaks. On the other hand the roentgenologist cannot approach the diagnostic angles unless he is interested in knowing the findings and viewing the specimens removed or observing the pathologic state at the time of the operation.

The great advances made in thoracic and cardiac surgery have been in no small way the result of the interdependence of these two fields of medical endeavor. It would be totally impossible to do good thoracic surgery without a most competent radiologic department. Likewise it would be impossible to have a good radiologic department from the standpoint of pulmonary disease unless the thoracic surgeon is willing to spend much time in consultation with the roentgenologist. A proper resident training program in both fields must realize this.

It has been a pleasure to greet this fine JOURNAL on the occasion of its fiftieth year of service to medicine. It is also an equal pleasure to see how much can be learned and done when man has learned that much more can be had when they strive together. As the poet Byron once said—"So much a long communion tends to make us what we are."



307 David Whitney Building
Detroit, Michigan

DR. WILLIAM J. CORCORAN
1895–1955

DOCTOR WILLIAM J. CORCORAN, 60, one of the most prominent roentgenologists in northeastern Pennsylvania died December 21, 1955. His death came on the last day of his term as President of the Lackawanna County Medical Society.

Doctor Corcoran received his education in the public schools of Old Forge, St. Thomas College, now the University of Scranton and his Doctor of Medicine Degree from Georgetown University.

Following an internship at the Allentown General Hospital, he opened an office in Old Forge for the practice of general medicine. After a long association with the late Doctor Byron Jackson, he established an office in Scranton, in 1936, in the field of roentgenology.

Doctor Corcoran was always actively interested in the problems of organized medicine as well as scientific medicine. For many years, he was the Editor of the *Reporter* (official Journal of the Lackawanna County Medical Society), in addition to which he served enthusiastically on committees pertaining to all phases of medicine. He was particularly interested in the study of anthracosilicosis, and published numerous papers before local and national societies.

He was Past President of the Pennsylvania Radiological Society, a Diplomate of the American Board of Radiology, a Fellow of American College of Radiology, a member of the Radiological Society of North America, The American Roentgen Ray Society, The Philadelphia Roentgen Ray Society and other scientific organizations.

He was Attending Radiologist at St. Mary's, Mercy, Moses Taylor, St. Joseph's in Carbondale, St. Joseph's Maternity, Scranton State, and Taylor Hospitals, and West Mountain Sanitarium.

He is survived by his wife, Mabel Corcoran, two sons, four daughters, five sisters and one brother.

Joseph J. O'Brien, M.D.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS*

OHIO STATE RADIOLOGICAL SOCIETY

The Annual Meeting of the Ohio State Radiological Society will be held May 11–13, 1956 at the Deshler-Hilton Hotel, Columbus, Ohio. Further information may be had by writing to John R. Hannan, M.D., 10515 Carnegie Avenue, Cleveland 6, Ohio.

LOW-BEER MEMORIAL FUND

A Bertram V. A. Low-Beer Memorial Fund has been established. Anyone who wishes to make a contribution may send a check to the fund at the Department of Radiology, University of California School of Medicine, San Francisco 22, California.

Money contributed to this fund is deductible when computing income tax.

THE AMERICAN COLLEGE OF RADIOLOGY

The following officers were elected at the recent Annual Meeting of the American College of Radiology: President, Dr. Wilbur Bailey, Los Angeles, California; Vice President, Dr. J. P. Rousseau, Winston-Salem, North Carolina; Member of the Board of Chancellors, Dr. Earl E. Barth, Chicago, Illinois; Member of the Board of Chancellors, Dr. Howard B. Hunt, Omaha, Nebraska.

FREEDMAN LECTURE

On Saturday and Sunday, April 28 and 29, 1956, Dr. J. Stauffer Lehman, Professor of Radiology, Hahnemann Medical School and Director of Department of Radiology, Philadelphia Hospital, will deliver the Eighth Annual Joseph and Samuel Freedman Lecture in Diagnostic Radiology at the University of Cincinnati College of Medicine. Radiologists desiring to attend are requested to write Dr. Benjamin Felson, X-ray Department, Cincinnati General Hospital, Cincinnati Ohio, for further details.

ROSS GOLDEN LECTURE

The Third Ross Golden Lecture was delivered by Dr. W. Edward Chamberlain, Professor of Radiology Temple University, on "Can We Afford Photofluorography?" at the New York Academy of Medicine, Monday evening, March 19, 1956, at 8:00 P.M. The lecture was sponsored jointly by Columbia University and the New York Roentgen Society.

COURSE IN ISOTOPES

The Medical Extension Division of the University of Southern California School of Medicine recently announced a course in "The Physics and Clinical Applications of Radioactive Isotopes," being held at the Los Angeles County Hospital and Cedars of Lebanon Hospital every Friday from 4–5 P.M. from February 10–June 22, 1956. This course is designed to give an over-all background in the clinical use of radioactive isotopes. Emphasis is placed upon the uses and limitations of radioactive isotopes as well as the physics involved.

We regret to announce the recent deaths of the following members of the American Roentgen Ray Society: Dr. Lyell Cary Kinney, San Diego, California; Dr. Walter H. Ude, Minneapolis, Minnesota; Dr. Jack Friedman, Minneapolis, Minnesota; Dr. John M. Barnes, Buffalo, New York; and Dr. Henry A. Cleaver, Wilmington, Delaware.

* The list of Meetings of Radiological Societies appears in the March, 1956, issue of the JOURNAL, and will be published in the May number.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

Die objektive Stereoskopie an Röntgenbildern; Eine diagnostische Methode. Von Prof. Dr. A. Hasselwander, Arlaching /Chiemsee. Cloth. Price, DM 27.—. Pp. 187, with 127 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1954.

The purpose of this monograph is to give detailed information about stereoscopy. The physical factors of the method, as well as the technical features, are treated at considerable length. To anyone who desires a really scientific study of this procedure this book will be of much help because of details which may be otherwise difficult to obtain.

The author describes the results of his many years of study of living and three-dimensional anatomy by means of stereoscopy. Half of the book deals with the application of this highly developed technique to many phases of surgery and clinical medicine.

Topographical-anatomical drawings of cross-sections of different regions of the body, done by the author, aid in the understanding of the stereoscopic localization of different portions of the body by means of roentgenography.

Hans W. Hefke, M.D.

On Burns. Compiled and edited by Nathan A. Womack, M.D., Professor of Surgery, University of North Carolina School of Medicine. Cloth. Pp. 191, with 7 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1953.

This is an excellent review of the treatment of burns covered from all standpoints and treated by experts in their respective fields. These men have outlined their opinions in this compact volume and I feel that a physician who is seeing and treating burns should include this book in his library. The treatment of open method of burns is discussed, as well as the very important early grafting, both homologous and autogenous skin grafting. There is a practical discussion on the important fluid balance, as well as the discussion on adrenal cortex in severe burns.

The questions which usually arise in the treatment of extensive burn such as, when to graft, what fluids to give, how to control infection, and delayed or early treatment are answered in very simple language in this book.

It not only treats the question of burns, but the book is so written that one feels that he is discussing a problem with an expert rather than just reading an ordinary textbook.

Edward H. Hill, M.D.

Endemic Goiter; the Adaptation of Man to Iodine Deficiency. By John B. Stanbury, M.D., Gordon L. Brownell, Ph.D., Douglas S. Riggs, M.D., Hector Perinetti, M.D., Juan Itoiz, Ph.D., and Enrique B. Del Castillo, M.D. Cloth. Price, $4.00. Pp. 209, with 53 illustrations and 17 tables. Harvard University Press, Cambridge, Massachusetts, 1954.

This study on endemic goiter was conducted by a group of investigators from Harvard Medical School and the Department of Medicine of the Massachusetts General Hospital, and of the Departments of Medicine, Biochemistry, and Surgery of the University of Cuyo and the Central Hospital of Mendoza, Argentina.

This book on endemic goiter can be reviewed by quoting from the résumé on the jacket. "This is the first complete account of the fundamental nature of endemic goiter as disclosed by newer methods of thyroid study, and the first attempt to give a complete and dynamic description of a complex metabolic process. The authors describe studies carried out upon goitrous patients in an area of Argentina known to be deficient in iodine."

"They have sought to define in quantitative terms the changes which occur when the thyroid gland seeks to compensate for iodine deficiency. In addition, they examine in detail the metabolism of iodine as disclosed by isotopic studies and give a comprehensive account of the dynamic processes involved in the synthesis and secretion of the thyroid hormones and the factors which govern the rate constants involved. The authors begin with a description

of the locale of the study in western Argentina and a clinical analysis of the patients who were used in the investigation, which they follow with a description of the methods employed and a detailed summary of the metabolism of iodine as clarified by recent medical research."

"The second section of the book is devoted to an analysis of the functional interrelations of the thyroid gland as disclosed by observations on 129 patients. The blood hormone iodine, the avidity of the thyroid for iodine, the rate of production of the thyroid hormone, and the supply of iodine in the diet are shown to constitute a complex interacting system For example, avidity of the gland for iodine is functionally related to iodine in the diet, and is vital in adaption to deficiency of iodine."

"The consequences of administration of supplementary doses of iodine, both when given daily and when given as a single dose are described, as are the effects of administration of desiccated thyroid."

"The third section deals with the dynamic aspects of iodine metabolism. After an exhaustive mathematical treatment based on hypothetical models the actual observations of radioactive iodine metabolism in patients with iodine deficiency are described. These observations extended over several weeks with each patient, and made it possible to test the validity of the models of iodine metabolism and to calculate the parameters of thyroid function. On an additional series of patients the effects of an antithyroid drug and of thyrotropic hormone are analyzed, as well as their effects on the rate constants of the metabolizing system."

"Similar observations were carried out on patients who received large doses of iodine after their thyroid glands had been labeled with radio-active iodine. Finally, the authors outline future areas of productive research suggested by these studies."

The authors were fortunate that the research project was finished in the nick of time for the sale of iodized salt was made mandatory in the Mendoza province. Their studies support the argument that lack of iodine is the principal etiological factor in endemic goiter.

Robert C. Moehlig, M.D.

The Chest; A Handbook of Roentgen Diagnosis. By Leo G. Rigler, M.D., Professor and Chief, Department of Radiology, University of Minnesota. Second edition. Cloth. Price, $8.00. Pp. 380, with 338 illustrations. Year Book Publishers, Inc., 200 East Illinois Street, Chicago 11, Illinois, 1954.

This book is especially well suited to the atlas method of presentation, characteristic of the "Hand Book of Roentgen Diagnosis" series. The normal variations and disease processes of the chest are presented by a man of vast experience in the diagnosis of chest diseases. The material adequately covers all phases of chest pathology in a concise manner. Salient features of chest diseases, together with illustrations of proved cases, are provided from the author's own files.

In this edition, the roentgen methods of examination of the chest are excellently presented with complete coverage of the newer techniques in bronchography and with new terminology and numerical designation of the bronchi. Material regarding the early diagnosis of lung tumors is also included. New illustrations have been added and other replaced. The author makes no pretense to be detailed or complete, but he condenses a tremendous amount into a few words, including many of the characteristic clinical and pathologic features of each disease. Some statements may seem somewhat dogmatic and material which might be controversial is excluded, but this adds to the brevity and clarity of the content. The illustrations are of excellent quality and amply emphazise the written material. The cases are well grouped and may serve as a guide for the analysis of any unusual roentgenogram. The book is well balanced, easily read and entirely practical.

K. K. Latteier, M.D.

Osteosklerose und Knochenmarkfibrose. Von Rudolph Stodtmeister, Dr. med. Dr. phil., apl. Professor für innere Medizin an der Universität Heidelberg. Chefarzt der Inneren Abteilung des Städtischen Krankenhauses Pforzheim; und Stefan Sandkühler, Dr. med., Assistent der Ludolf-Krehl-Klinik (Medizin, Univ.-Klinik) Heidelberg; unter röntgenologischer Mitarbeit von Albert Laur, Dr. med., Assistent der Röntgenabteilung der Ludolf-Krehl-Klinik (Medizin. Univ.-Klinik) Heidelberg. Cloth. Price, DM 28.50.—. Pp. 135, with 29 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1953.

This monograph of 135 pages is probably the

first to appear about this subject. It appears appropriately at a time when medicine tries to unite the specialistic findings of its many branches into a unity of concepts of diagnosis and treatment. The clinical, radiologic and pathologic aspects of sclerosing and fibrosing diseases of bones are described; all equally well, but with predominant attention to the clinical aspect.

The first chapter deals with osteopetrosis (Albers-Schoenberg's disease). The different features of the clinical, roentgenologic and pathologic aspects are described in detail. An extensive bibliography of the European and American literature is appended. In the second chapter a group of congenital periosteal hyperostoses is dealt with, as Camurati- Engelman's disease and a generalized periosteal hyperostosis of puberty and adolescence. In succeeding chapters the generalized infantile hyperostosis (Koszewski), as well as different types of toxic osteoscleroses, is discussed. The relatively little known osteomyelosclerosis (Henck) with variants is dealt with in great detail. The clinical and pathologic findings of the medullary fibrosis of bones occupy many pages of the treatise.

These neither common nor rare diseases which lead to sclerotic changes in the bone marrow often also cause blood abnormalities. Differential diagnostic considerations are of considerable value to the clinician.

Hans W. Hefke, M.D.

Applicazioni della stratigrafia assiale trasversa in pediatria. By R. Bulgarelli, G. Sansone, C. Lombroso, G. Corradi, P. Durand, E. de Toni, Instituto di Clinica Pediatrica dell'Università di Genova, Direttore: Prof. G. de Toni; A. de Maestri, N. Macarini, L. Oliva, Instituto di Radiologia dell'Università di Genova, Direttore: Prof. A. Vallebona. Paper. Price, L. 2000. Pp. 350, with numerous illustrations. Edizioni Minerva Medica, Torino, Italy, 1951.

This book begins with a brief exposition on the fundamental principles of the usual stratigraphy. Then the geometrical foundation of transverse axial stratigraphy is explained and illustrated with diagrams. It gives details of the research and development of this type of radiography by Vallebona and his co-workers, with the first announcement of this work in 1947. This method of examination now makes it possible to obtain cross-section studies and has added a third-dimensional aspect to roentgenography. It has found numerous applications in medical and surgical problems. Its use in diseases of children is the subject of this book.

Each chapter takes up in detail, with case reports and numerous roentgenograms, how transverse axial stratigraphy may be combined with routine radiographs and usual stratigraphy to supplement our knowledge in normal and pathologic conditions of the various organs. The diagnosis in patients used for study, has been confirmed either by autopsy, surgical exploration or other accepted methods.

Hypertrophy of the thymus gland was studied with transverse stratigraphy in association with pneumomediastinum. By separation of the mediastinal structures with air, with cross-sections taken at different levels of the thorax, the thymus gland is clearly visualized in the retrosternal area.

The first contribution to the literature is reported in the study of the patent ductus arteriosus by transverse axial stratigraphy. Besides studies with conventional films, frontal stratigraphy was also used in the study of these cases. The transverse axial films were taken at eight different levels of the thorax. The possibilities of utilizing this method of investigation in acquired and congenital heart diseases are discussed.

In the study of several cases of tetralogy of Fallot and in one case of Eisenmenger's complex, the authors used this method in association with anterior pneumomediastinum and frontal stratigraphy. The authors were impressed by the clear demonstration of the exact location and size of the aortic arch and the degree of dextroposition of the aorta. The size of the superior vena cava could be determined. The degree of pulmonary ischemia could be well estimated in the cases of tetralogy. The authors feel that the heart size and shape has characteristic appearances in the axial stratigrams. The transverse axial stratigrams were repeated in four cases after the Blalock-Taussig operation to study the changes resulting in the pulmonary circulation.

A case of double aortic arch associated with probable ventricular septal defect, and two proved cases of ventricular septal defect were

studied by this method. Characteristic findings may prove of great importance in the diagnosis of ventricular septal defects by transverse axial stratigraphy.

A group of acquired heart diseases was also studied. Cases of rheumatic heart disease with mitral stenosis, both uncomplicated and complicated, were studied in relation to enlargement of the various chambers of the heart. In their conclusions, the authors feel that characteristic changes in the heart shadow are noted by transverse axial stratigraphy so that single chamber enlargements or more than one chamber enlargement can be detected accurately with this method.

This method was also applied to the study of abdominal organs in association with precoccygeal air insufflation. In the cases illustrated good visualization of the kidneys, liver and spleen was obtained in cross-section views.

A new procedure is described to produce artificial pneumomediastinum, injection of gas (oxygen) in the epidural space just above the superior surface of the body of the 12th dorsal vertebra. This puncture is fairly easy to perform in young patients, with very little discomfort or danger. In the older children as much as 500–600 cc. of gas have been injected. After the air injection, routine roentgenograms are made including lateral projections. Further exposures were made with frontal, lateral and transverse axial stratigraphy. Clear cut visualization of the aorta and other large vessels of the mediastinum is possible. The injection of gas using this method produces both an anterior and posterior artificial pneumomediastinum with a single injection.

A new method for direct visualization of the pancreas is described. A combination of retroperitoneal insufflation, gastric gaseous insufflation and stratigraphy, lateral and transverse axial, are used in this procedure. Four cases are reported and illustrated in detail and the reproductions are convincing evidence that the substance of the pancreas can be seen. The importance of future investigation of this scarsely explored organ because of its peculiar location is stressed.

After surmounting the numerous difficulties in the proper immobilization of the infant, pneumoencephalography and transverse axial stratigraphy was successfully accomplished. The ventricular system and the basilar cisterna were clearly outlined by this procedure. The urinary bladder in infants was subjected to research studies using the transverse axial stratigraphy.

This book of 350 pages, containing a large number of illustrations, diagrams and reproductions, is devoted to research work on transverse axial stratigraphy in children. The amount of original investigation in this field is tremendous. It has given the radiologist a means, or a tool for study of the organs in the third dimension. The importance of cross-section anatomy is revived by this method. Although much of this field will remain in the realm of research, the amount of knowledge to be gained appears to be significant in the study of normal and pathologic organs.

P. E. RUSSO, M.D.

ATLAS OF EXFOLIATIVE CYTOLOGY. By George N. Papanicolaou, M.D., Ph.D., Clinical Professor of Anatomy Emeritus, Cornell University Medical College. Looseleaf. Price. $18.00. Pp. 56, with numerous color plates and accompanying notes. Published for The Commonwealth Fund by Harvard University Press, Cambridge, Massachusetts, 1954.

Exfoliative cytology may be said to be growing out of its infancy. Despite the essential element of time that must be consumed in the training of technical personnel to serve as assistants in screening of smears, and of pathologists who examine and interpret the cells, the method is steadily gaining in adoption. In addition, the particular fields of its usefulness are being defined.

The Atlas of Exfoliative Cytology by Papanicolaou, the modern advocate and leading teacher of this branch of morphologic anatomy and pathology, is a basic reference for all workers in the field. The volume has been prepared in attractive loose-leaf publication of stout structure. The text is not excessive, is printed in double-column format, and is abundantly illustrated by 36 plates in color, 24 being drawings and 12 photomicrographs, all exquisitely presented and of surpassing quality. The techniques of obtaining materials from various sources are outlined in 11 pages, and the criteria of malignancy in 8 pages. Most space is devoted to cytology of the female genital system (13 pages of text and 12 plates) but separate sections are also given to cytology of uri-

nary and male genital system, respiratory system, digestive system, exudates, breast, and miscellaneous cells. At present pathologists who have adopted the method generally place most confidence in their ability to interpret the significance of exfoliated cells obtained from the cervix uteri, the bronchus, pleura, peritoneum and nipple.

Exfoliative cytology must not be regarded as a substitute for biopsy. Although it often furnishes presumptive evidence for cancer, if possible and feasible, confirmation of the interpretation should be sought in biopsy. The author points out that an essential feature of exfoliative cytology lies in the degenerative changes of the desquamating cells which give the cells their specific morphologic characteristics. The cytologic method is concerned with the recognition of cells and their classification in one of the following five categories: normal, atypical, suggestive of malignancy, strongly suggestive of malignancy, conclusive for malignancy.

Of interest to radiologists are the striking cellular and nuclear abnormalities that occur as a result of irradiation. Exfoliated squamous cells, both normal and abnormal, may present changes that are extreme during the first two weeks after irradiation. Following irradiation, the distinction between malignant and nonmalignant exfoliated cells, particularly squamous cells, may be difficult. Desquamated irradiated cells are commonly necrotic and hence are often invaded or surrounded by leukocytes. After irradiation for carcinoma of the cervix it is often difficult to decide if atypical cells represent postradiational effect on normal cells or indicate recurrence or residual tumor. Furthermore, atypia of nonmalignant cells may persist for many months and sometimes for years following radiation. The author states that the evaluation of squamous cells in sputum or bronchial aspirate from patients irradiated for carcinoma of the bronchus, is less difficult than in smears from patients irradiated for squamous cell carcinoma of the cervix. Generally, however, malignant cells disappear from the smear in from two to four weeks after effective irradiation. Their persistence after that time, therefore, implies an unfavorable prognosis.

In addition to a selective bibliography, the value of this choice atlas is enhanced by a helpful index. By virtue of its loose-leaf arrangement, the atlas is designed to accept readily inserts of revised or new information that must come with our increasing knowledge of the usefulness and limitations of the method. By this means, the atlas is assured a long and useful life.

S. E. Gould, M.D.

Radio-Anatomie Générale de la Tête. Par Robert Aubaniac, Agrégé d'Anatomie, and Jacques Porot, Assistant d'Electro-Radiologie des Hôpitaux de Paris. Paper. Price, 5.000 fr. Pp. 152, with numerous illustrations. Masson et Cie, Editeurs, 120 boulevard Saint-Germain, Paris-6e, 1955.

Strong emphasis is placed upon the necessity of teaching normal roentgen anatomy in the present day training of radiologists. The material represented in this work has been rigorously selected in order to assure the absence of any suggestion of pathologic cases. The roentgenologic details of the tissues in the individual planes have been recorded by films of each of multiple anatomic sections in three planes—frontal, sagittal, and horizontal—and numerous drawings prepared from these roentgenograms. Many of the roentgenograms themselves have been reproduced in this work. The commentary in the various sections constitutes an important part of the instructional material. The studies included in this work should not be confounded with tomographic studies, but they are of inestimable value in the interpretation of tomograms. The alphabetical index, including about 500 of the important anatomic references, is an exceptionally fine contribution to the value of the book. This book would seem to supplement and complement another publication by Masson et Cie entitled *Roentgenographic Anatomy of the Facial Bones*, by Bouchet and Dulac and Pailler. The two publications together constitute a complete and unusually attractive contribution to the roentgen anatomy of the head and face.

James T. Case, M.D.

Anatomie Radiographique du Massif Facial. Par Maurice Bouchet, Oto-rhino-laryngologiste des Hôpitaux de Paris; and Georges Dulac, Électro-radiologiste, Ancien Chef de service de la Fondation Curie. Cloth. Price, 2.800 fr. (paper); 3.600 fr. (cloth). Pp. 188, with 103 illustrations. Masson et Cie,

Éditeurs, 120 boulevard Saint-Germain, Paris-6e, 1955.

This is a volume of 187 large pages (9 by 12 inches), with 103 figures. This excellent book was designed to facilitate the interpretation of such roentgenograms of the facial bones as are in daily usage in the diagnosis of diseases of the nasal accessory sinuses and the nasal fossae. The progress achieved in recent years in the study of sinus pathology has been based principally on roentgenographic studies. The mere interpretation of "clear sinuses" and "clouded sinuses" has become "terribly insufficient." The deformity or disappearance of a bony contour may signify a mucocele, caseous sinusitis or malignant tumor. The disappearance of a certain bony contour may signify an inoperable malignant tumor. The utilization of contrast studies, either by injection or by the method of Proetz, and especially tomography, has permitted recognition of the thickness of the mucosa of the sinuses, the existence of and the significance of intrasinus cysts, and the exact relation between the maxillary cavity and the adjacent ethmoidal cavities. These are only some of the advantages offered by this work.

Part I comprises the following divisions: General definition of projections; schematic drawings based on progressive reconstruction of anatomic sketches from roentgenograms in the various projections. Oblique incidence is recommended almost systematically, and tomography is extensively employed. Drawings are provided showing all of these projections.

Part II includes exercises in interpretation of roentgenograms made according to the fundamental projections described. Each roentgenographic illustration is accompanied by a very accurate sketch and an anatomic and radiographic description. The work should interest not only otorhinolaryngologists and radiologists, but also stomatologists and specialists in maxillofacial surgery as well as neurosurgeons. It is an excellent publication, a beautiful example of the printer's art.

James T. Case, M.D.

Consolidated Indices. Volume IV. Author and Subject: 1948–1952 (Vol. 59–68), of The American Journal of Roentgenology, Radium Therapy & Nuclear Medicine. Compiled under the direction of the Publication Committee and the Editorial Office of the American Roentgen Ray Society. Cloth. Price, $13.50. Pp. 486. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1955.

Volume IV, of the Consolidated Indices, has followed the helpful changes that have been made in the preparation of Volume III. Any given subject entry and the name or names of authors appear so that if one desires to consult a particular subject by a given author, the information is readily accessible. There is no separation of authors in subjects, but the authors appear throughout the index in proper alphabetical order. The volume numbers of The American Journal of Roentgenology, Radium Therapy, & Nuclear Medicine appear in bold-faced Arabic type rather than in Roman numerals. The type is slightly larger and most readable.

The Editor and those who collaborated in the preparation of Volume IV are to be complimented on the excellence of the Consolidated Indices. These Indices have been prepared so thoroughly that they are most usable; not only has each article been indexed but each article and volume have been indexed page by page similar to that observed in the better textbooks. Original articles, editorials, obituaries, all material appearing in the Department of Correspondence, Book Reviews and Abstracts have been carefully and thoroughly indexed both as to subjects and authors.

The Consolidated Indices meets the requirements of the most discriminating reader. It will fill the needs of the medical and the allied professions in making available the vast amount of material which has appeared in The American Journal of Roentgenology, Radium Therapy & Nuclear Medicine. One cannot be too enthusiastic about this volume. The Consolidated Indices should continue to be a source of satisfaction to those who have made this work possible and to its Publisher, Mr. Charles C Thomas and his staff who are to be complimented on the excellence of the paper that has been used, the type and design of its physical qualities.

Eugene P. Pendergrass, M.D.

Analytical Cytology. Newer Methods for Studying Cellular Form and Function. Edited by Robert C. Mellors, M.D., Ph.D.,

Division of Experimental Pathology, Sloan-Kettering Institue for Cancer Research and Pathology Laboratories, Memorial Center for Cancer and Allied Diseases, and Graduate School of Medical Sciences, Cornell University Medical College. Cloth. Price, $15.00. Nine chapters, individually paged, with numerous illustrations. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York, 1955.

This volume is a comprehensive survey of the recent developments in the field of analytical cytology. It is a collection of monographs dealing with methods employing the optical spectral region and those using electrons, radioactive isotopes, and roentgen rays. The nine sections include: cytophotometric analysis in the visible spectrum; histochemical and cytochemical staining; phase-contrast, interference contrast, and polarizing microscopy; ultraviolet microscopy and microspectroscopy; fluorescence microscopy; electron microscopy; radioautography and its use in cytology; historadiography; and roentgen-ray diffraction techniques and their application to the study of bimolecular structures. The last three sections should be of particular interest to the radiologist and emphasize the value of close liaison in research between the specialties of radiology and pathology. Excellent bibliographies are found throughout the book. It should prove a valuable guide for investigators in cyto-physiology and cytopathology.

Edwin M. Knights, Jr., M.D.

Lipoproteins in Serum, from Normal Persons and from Patients with Chronic Liver Diseases. The Scandinavian Journal of Clinical & Laboratory Investigation, Supplement 21. By Inger-Louise Marner. Paper. Pp. 182, with numerous illustrations and tables. The Scandinavian Journal of Clinical & Laboratory Investigation, Medical Department A., Rikshospitalet, Oslo, Norway, 1955

This monograph deals with the study of lipoproteins in serum in normal and cirrhotic patients by means of fractionation by the Tiselius electrophoresis apparatus It is a good source of reference for those interested in the study of sera from "normal" patients or those suffering from various types of chronic liver disease, and includes a chapter comparing investigations by zone electrophoresis and free electrophoresis.

Edwin M. Knights, Jr., M.D.

The Hypophyseal Growth Hormone, Nature and Actions. Editors: Richmond W. Smith, Jr., M.D., Physician-in-Charge, Division of Endocrinology, Henry Ford Hospital, Detroit; Oliver H. Gaebler, M.D., Head, Biochemistry Department, Edsel B. Ford Institute for Medical Research, Detroit; C. N. H. Long, M.D., Sterling Professor of Physiology, Yale University School of Medicine New Haven. Cloth Price, $12.00. Pp. 576, with numerous illustrations. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, 1955.

This "Symposium was sponsored by the Henry Ford Hospital and Edsel B. Ford Institue for Medical Research in Detroit, Michigan, and held at the Hospital, October 27, 28, 29, 1954."

Forty-five participants from Canada, Argentina, England and the United States gave papers covering the field of knowledge on the hypophyseal growth hormone. There were three Nobel prize winners among the participants (Charles H. Best; Carl F. Cori; and Bernardo A. Houssay) and the remainder were outstanding research and investigative workers. This formidable array of talent would in itself guarantee a fine contribution and such it is. Many scientific fields were represented, "Anatomists, physiologists, biochemists, pharmacologists, zoologists and investigators in endocrinology, animal husbandry and clinical medicine."

The introductory address was given by Paul Weiss of the Rockefeller Institute for Medical Research in New York. The title of his address was "What is Growth?" The contents following the introduction are divided as follows: 1. Bioassay; Preparation and Physicochemical Properties of Growth Hormone; 2. Effects of Growth Hormone on Certain Structures; 3. Growth Hormone and Energy Sources; 4. Growth Hormone and Cellular Systems; 5. Influence of Growth Hormone on the Mammary Gland and on Human Metabolism.

It is difficult to select any particular contribution from this symposium for commendation, much depending upon the interests of the reviewer. That of Asling, Simpson (Dr. Miriam E.) who read the paper; Moon, Li and Evans,

from the Institute of Experimental Biology, University of California, Berkeley, was especially interesting. These workers investigated the "skeletal abnormalities induced in the rat by growth hormone, with particular emphasis on the changes in and about the joints in order to determine whether or not they represent acromegalic osteoarthropathy."

Part of the summary reads "In addition to the anticipated gigantism, multiple bone and joint abnormalities occurred in rats injected chronically with growth hormone. The changes were more numerous and more severe in the hypophysectomized injected rats than in intact rats similarly treated. Only a few abnormalities of the types noted in experimental groups were seen in their respective controls."

"Counterparts are found in human acromegaly for the majority of the proliferative processes here described and for the gross deformities which result."

The closing remarks of Dr. C. N. Long make great reading and curb the premature enthusiasm of those who believe that final conclusions have been reached concerning this interesting gland. His introductory paragraph in these closing remarks bears repeating. "It must be obvious to all who have heard the papers given in this room during the last three days that any attempt to draw final conclusions concerning the chemistry or the physiologic and metabolic effects of the growth hormone would not only be untimely but a task beyond the power of one individual to accomplish. The failure of any such attempt is, obviously, not due to lack of experimental data; indeed one of the most impressive aspects of the meeting is the realization that such a large number of individuals on both sides of the Atlantic are engaged in such a variety of studies on this hormone. Rather, it is to be attributed to certain unique peculiarities of the organ that produce this agent."

The editors are to be praised for getting the volume into print so soon after the presentation of the symposium. It unquestionably will become a source of frequent references in the endocrine literature.

Robert C. Moehlig, M.D.

Der Herzkatheterismus bei angeborenen und erworbenen herzfehlern. Von Prof. Dr. Otto Bayer, Oberarzt der I. Med. Klinik Düsseldorf; Dr. Franz Loogen, Assistent der I. Med. Klinik Düsseldorf; and Dr. Hans Helmuth Wolter, Assistent der I. Med. Klinik Düsseldorf. Cloth. Price, $8.60. Pp. 191, with 131 illustrations. Georg Thieme Verlag, Stuttgart, Herdweg 63, Germany, 1954.

This book represents an excellent description of the technique of catheterization data obtained in congenital and acquired heart disease. In an introductory chapter, the authors deal with the technique of catheterization, and with the analytical methods. This reviewer was particularly interested in the use of a stylet during catheterization, which is found of great value in some laboratories in the United States. The analytical methods differ somewhat from those used in this country; for instance, the hemoreflector is rarely used in America, whereas the Haldane apparatus is often replaced by a Pauling oxygen analyzer or by a Scholander apparatus. Of interest here is the fact that the authors use the ether test of Donzelot to demonstrate the location of an intracardiac shunt.

The reviewer does not quite believe in the statement that the pulmonary capillary pressures represent a true image of the left atrial pressure. He also would have liked to have seen some mention of the origin of the concept "effective pulmonary blood flow."

The classification of congenital heart disease is good, and the diagrams describing the physiologic findings in the various cardiac malformations are excellent.

The book is highly recommended for those who are primarily interested in techniques and diagnosis. It is hoped that the authors will follow this volume with a second one discussing some of the important general findings which have been accumulated through the use of the intracardiac catheter (mechanism of primary pulmonary hypertension, etc.).

Richard J. Bing, M.D.

Tumours of Lymphoid Tissue. By George Lumb, M.D., Reader in Pathology, Westminster Medical School, London University; Consultant Pathologist, Westminster Hospital; Lecturer in Pathology, Institute of Basic Medical Sciences, Royal College of Surgeons of England. Cloth. Price, $8.00. Pp. 204, with numerous illustrations. (Printed in Great Britain by E. & S. Livingstone Ltd.)

Williams & Wilkins Co., Mt. Royal and Guilford Avenues, Baltimore 2, Maryland, 1954.

This book is based on the author's study of 410 patients with tumors of the lymphoid system. The author's classification and terminology are clearly defined and presented and are augmented by photomicrographs of exceptional quality. Statistical data and typical case histories are included. Unfortunately the bibliography does not include many recent contributions (*e.g.*, on antibody formation and chemotherapy), and some sections of differential diagnosis (*e.g.*, infectious mononucleosis and mycosis fungoides) are rather brief. A discussion of the imprint method of lymph node study might well have been included under the section on diagnostic techniques.

This book is a brief, but well-illustrated review of lymphoid tumor pathology.

Edwin M. Knights, Jr., M.D.

Fourth Annual Report on Stress. By Hans Selye, M.D., Ph.D. (Prague), D.Sc. (McGill), F.R.S. (Canada), F.I.C.S. (Hon.) Professor and Director, Institut de Médecine et de Chirurgie expérimentales, Université de Montréal; and Gunnar Heuser, M.D. (Cologne), Research Assistant and Librarian of the Institute. Cloth. Pp. 749, with illustrations. Acta, Inc., 5465 Decarie Boulevard, Montreal 29, Quebec, Canada, 1954.

In this fourth volume on Stress, we are again treated to a tremendous amount of work culled from the world literature resulting in 4,828 references requiring 151 pages. In addition there are 42 pages of references which complement the former by alphabetically arranged cross-references. Selye and Heuser's technical and secretarial staff consisted of six individuals—in addition to editorial assistance from Maria Schwappach.

Selye continues to broaden the stress concept so that it encompasses every field of medicine.

In the present volume are articles by ten specialists in various fields—these are:

Asboe-Hansen, G.: "The Skin and the 'Adaptive' Hormones."

Harris, G. W. and C. Fortier: "The Regulation of Anterior Pituitary Function with Special Reference to the Secretion of Adrenocorticotrophic Hormone."

Bacchus, H.: "Ascorbic Acid and the Physiology of the Pituitary Adrenal Axis."

Brochner-Mortensen, K.: "Prolonged Treatment of Rheumatoid Arthritis with Cortisone."

Copeman, W. S. C. and O. Savage: "ACTH and Cortisone in Rheumatoid Arthritis."

Grollman, A.: "Hypertension."

Moore, F. D.: "Bodily Changes in Surgical Convalescence, a 1954 Revision."

Simpson, S. A. and J. F. Tait: "Aldosterone and Its Possible Role in the General Adaptation Syndrome."

Sonenberg, M.: "The Metabolism of Anterior Pituitary Hormones."

Stamler, J., L. N. Katz and R. Pick: "Nutritional-Endocrinological Interrelationships in the Pathogenesis of Hypertension and Atherosclerosis over the Life Span."

Selye says, "The fact certain corticoids (*e.g.*, cortisone; cortisol) inhibit while others (*e.g.*, D.C.A.) stimulate inflammation is now so generally accepted that it hardly deserves much comment."

He terms these "antiphlogistic corticoids and prophlogistic corticoids." He says that as advances are made modifications of the adaptation syndrome must naturally follow. He again states that "these books are obviously not meant to be read from cover to cover." Anyone who is interested in stress, should consult these volumes. It is always a source of amazement to the reviewer how much meticulous work goes into compiling these interesting volumes. There are now some 25,000 references on stress and thus it is evident that Selye and associates have at the University of Montreal the largest library on stress in the world. The senior author shares with his associates the distinction of compiling a monumental work which will have a prominent place in medical history.

Robert C. Moehlig, M.D.

BOOKS RECEIVED

Peripheral Vascular Diseases. By Edgar V. Allen, B.S., M.A., M.D., M.S. in Medicine, F.A.C.P., Section of Medicine, Mayo Clinic; Nelson W. Barker, B.A., M.D., M.S. in Medicine, F.A.C.P., Section of Medicine, Mayo Clinic; and Edgar A. Hines, Jr., B.S., M.A., M.D., M.S. in Medicine, Section of Medicine, Mayo Clinic; with Associates in the Mayo Clinic and Mayo Foundation. Second edition. Cloth. Price, $13.00. Pp. 825,

with 316 illustrations. W. B. Saunders Company, West Washington Square, Philadelphia 5, Pennsylvania, 1955.

Obstetrical Roentgenology. By Robert Berman, M.D., F.A.C.S., Assistant Clinical Professor of Obstetrics and Gynecology, New York University College of Medicine. Cloth. Price, $12.50. Pp. 560, with 486 illustrations. F. A. Davis Company, 1914 Cherry Street, Philadelphia, Pennsylvania, 1955.

Pathology for the Surgeon. By William Boyd, M.D., Lecturer on the Humanities in Medicine, The University of Toronto, Visiting Professor of Pathology, The University of Alabama. Seventh edition. Cloth. Price, $12.50. Pp. 737, with 547 illustrations. W. B. Saunders Company, West Washington Square, Philadelphia 5, Pennsylvania, 1955.

Klinische Fehldiagnosen. Von Prof. Dr. M. Bürger, Direktor der med. Universitätsklinik, Leipzig. Cloth. Price, $14.15. Pp. 500, with numerous illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1954.

Funktionelle Röntgendiagnostik der Halswirbelsäule. Von Dr. C. Buetti-Bäuml, Priv.-Dozent Universitäts-Röntgeninstitut Basel. Cloth. Price, DM 42.—. Pp. 160, with numerous illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1954.

Consolidated Indices. Volume IV. Author and Subject: 1948–1952 (Vol. 59–68), of The American Journal of Roentgenology, Radium Therapy & Nuclear Medicine. Compiled under the direction of the Publication Committee and the Editorial Office of the American Roentgen Ray Society. Cloth. Price, $13.50. Pp. 486. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois, 1955.

Clinical Roentgenology. Volume III. The Lungs and the Cardiovascular System, Emphasizing Differential Considerations. By Alfred A. de Lorimier, M.D., Radiologist, Saint Francis Memorial Hospital, San Francisco, California; Henry G. Moehring, M.D., Radiologist, Duluth Clinic, Duluth, Minnesota; John R. Hannan, M.D., Radiologist, Cleveland, Ohio. Cloth. Price, $20.50. Pp. 508, with numerous illustrations. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois, 1955.

Maladies des os et des Articulations. Par Stanislas de Séze, Professeur agrégé à la Faculté de Médecine de Paris, Médecin de l'Hôpital Lariboisière, and Antoine Ryckewaert, Médecin-Assistant des Hôpitaux de Paris. Cloth. Price 9.300 fr. Pp. 1240, with 391 illustrations. Éditions Médicales Flammarion, 22, rue de Vaugirard, Paris —VI^e, France, 1954.

Atlas of Roentgen Anatomy of the Skull. By Lewis E. Etter, B.S., M.D., F.A.C.R., Assistant Professor of Radiology, School of Medicine, University of Pittsburgh. With a section on: The Radiographic Anatomy of the Temporal Bone. By J. Brown Farrior, M.D., F.A.C.S., and a section on: The Roentgen Anatomy of the Skull in the Newforn Infant. By Samuel G. Henderson, M.D., F.A.C.R., and Louise S. Sherman, B.S., M.D. Cloth. Price, $14.75. Pp. 215, with 239 illustrations. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois, 1955.

Das transversale Schichtverfahren. Von Doz. Dr. Med. Alfred Gebauer, Frankfurt a.M.; and Dr. Med. Alfred Schanen, Bremen. Cloth. Price, $23.20. Pp. 313, with numerous illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1955.

Obstetrics. By J. P. Greenhill, M.D., Senior Attending Obstetrician and Gynecologist, The Michael Reese Hospital; Obstetrician and Gynecologist, Associate Staff, The Chicago Lying-in Hospital; Attending Gynecologist, The Cook County Hospital; Professor of Gynecology, Cook County Graduate School of Medicine. Eleventh edition. Cloth. Price, $14.00. Pp. 1008, with 910 illustrations, 144 in color. W. B. Saunders Company, West Washington Square, Philadelphia 5, Pennsylvania, 1955.

Roentgen Interpretation. By George W. Holmes, M.D., Honorary Physician, Massachusetts General Hospital; Clinical Professor of Roentgenology, Emeritus, Harvard Medical School; Radiologist to the Waldo County Hospital Belfast, Maine; and Laurence L. Robbins, M.D., Radiologist-in-Chief to the Massachusetts General Hospital; Associate Clinical Professor of Radiology, Harvard Medical School. Eighth edition. Cloth. Price, $10.00. Pp. 525, with 371 illustrations. Lea & Febiger, 600 South Washington Square, Philadelphia, 1955.

Klinische Elektrokardiographie. Von Dr. M. Holzmann, Zürich. Third edition. Cloth. Price, DM 80.—. Pp. 688, with 303 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1955.

Dental and Oral X-Ray Diagnosis. By A. C. W. Hutchinson, D.D.S., M.D.S., F.D.S., F.R.S.E., Professor of Dental Surgery, University of Edinburgh. Cloth. Price, $15.00. Pp. 524, with 946 illus-

trations. The Williams & Wilkins Co., Baltimore 2, Maryland, 1954.

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Recent Advances in Radiology. By Thomas Lodge, M.B., Ch.B. (Sheff.), F.F.R., D.M.R., Consultant Radiologist, United Sheffield Hospitals; Consultant Radiologist, Sheffield Regional Hospital Board, Clinical Teacher in Radiodiagnosis, University of Sheffield; Hon. Editor, Journal of the Faculty of Radiologists. Third edition. Cloth, Price, $10.50. Pp. 358, with 182 illustrations. Little, Brown and Company, 34 Beacon Street, Boston 6, Massachusetts, 1955.

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Fourth Annual Report on Stress. By Hans Selye, M.D., Ph.D. (Prague), D.Sc. (McGill), F.R.S. (Canada), F.I.C.S. (Hon.), Professor and Director, Institut de Médecine et de Chirurgie experimentales, Université de Montréal; and Gun-

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Handbook of Toxicology. Volume I. WADC Technical Report 55-16. Edited by William S. Spector. Paper. Pp. 408. Wright Air Development Center, United States Air Force, Wright-Patterson Air Force Base, Ohio, 1955.

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Die genuine Vitamin D-resistente Rachitis. Von Dr. Walter Swoboda, Assistent der Universitätskinderklinik Wien. Paper. Price, $2.50. Pp. 79, with numerous illustrations. Wilhelm Maudrich, Publisher, IX., Spitalgasse 1b, Vienna, Austria (U. S. representative: Intercontinental Medical Book Corporation), 1956.

Intestinal Obstructions. By Owen H. Wangensteen, B.A., M.D., Ph.D., Professor of Surgery, University of Minnesota, Minneapolis, Minnesota. Third edition. Cloth. Price, $15.50. Pp. 838, with 200 illustrations and 66 tables. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois, 1955.

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

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ROENTGEN DIAGNOSIS

Head

Fischgold, H., Juster, M., and Metzger, J. Image radiographique de la fenêtre ovale. (Roentgenographic image of the oval window.) *Acta radiol.*, July, 1955, *44*, 33–38. (From: Clinique Neuro-Chirurgicale de la Pitié, Section Neuro-Radiologie, Paris, France.)

Connecting the middle ear with the internal ear, the oval window separates two mediums of transmission of sound waves; the solid chain of the ossicles and the peri- and endolymphatic liquid of the labyrinth. It is difficult to demonstrate the oval window routinely on roentgenograms.

The subject is placed in the Chaussé III position. In this position the patient is prone and the head is inclined toward the side being examined so that the sagittal diameter forms an angle of 15 degrees with the perpendicular. A tube with a 0.3 mm. focus is 25 cm. beneath the table and the film is 25 cm. above the head, thus giving an enlarged roentgenogram. The central ray is directed perpendicularly upward through the anterior portion of the temporal fossa and thus directly through the region of the oval window.—*Charles M. Nice, Jr., M.D.*

Patey, David H., and Thackray, A. C. Chronic "sialectatic" parotitis in the light of pathological studies on parotidectomy material. *Brit. J. Surg.*, July, 1955, *43*, 43–50. (From: Surgical and Pathological Departments, Middlesex Hospital, London, England.)

Nine cases of chronic "sialectatic" parotitis, 8 of which were treated by conservative parotidectomy, *i.e.*, parotidectomy with conservation of the facial nerve, are reported. Clinically two types are presented—inflammatory obstructive and tumor simulating. Plain films and sialograms were usually made, and in certain instances roentgenograms were made of the removed gland. Multiple microcalculi were occasionally found, chiefly in the specimens of the removed material. The principal finding was sialectasis, mainly of the intermediate and smaller sized ducts. Pathologic examination has revealed that this interpretation is incorrect since the chief cause of the dilatations is extravasation of the lipiodol interstitially. Large pools of lipiodol sometimes interpreted as indicating abscesses are often merely extreme examples of such extravasation. The other principal roentgen finding—the tendency for lipiodol to be retained in the gland—is likely explained on this same basis. Residual lipiodol has been demonstrated roentgenographically when the sialography had been carried out weeks, months or years before.

When the inflammatory process is advanced, the glandular substance may either be replaced by large aggregations of lymphoid tissue or obliterated by hyperplastic and metaplastic changes in the epithelium of the ducts. Lymphoid tissue may cause a local lump clinically, and a filling defect in the typical sialectatic picture roentgenographically. The ducts may be obliterated by hyperplastic tissue and, of course, fail to fill.

Thinning and fragmentation of the connective tissue walls of the intralobular ducts occur at an early stage and it is through these weakened ducts that extravasation of lipiodol occurs during sialography. While sialography may be useful in excluding cases of chronic sialectasis by showing a normal duct system not possible by plain films, the danger of permanent extravasation in other cases of chronic parotitis must be kept in mind. It is considered advisable to introduce much smaller quantities ($\frac{1}{4}$–$\frac{1}{2}$ cc.) instead of the usual 2–3 cc. Injections of amounts greater than $\frac{1}{2}$ cc. should be done with great caution and under careful roentgen control.

The cause of chronic "sialectatic" parotitis is unknown. In the tumor simulating type and in disabling degrees of the inflammatory obstructive groups, conservative parotidectomy may be of great value.—*Chauncey N. Borman, M.D.*

Neck and Chest

Di Guglielmo, L., and Bonomo, B. The significance of the lateral subsegments of the lung in pulmonary disease: a review of 500 cases. *Acta radiol.*, Sept., 1955, *44*, 217–229. (From: Institute of Radiology, University of Pavia, Italy, and Roentgen Department I, Södersjukhuset, Stockholm, Sweden.)

The lateral regions of the lungs, even if classified as subsegments, are of considerable importance, being often the seat of a large number of morbid processes. The roentgenologic characteristics of consolidations in these areas are clear-cut and constant. The recognition of the existence of these areas will provide means of precise localization.

A lateral situation was found in 23 per cent of 500 cases. The upper lobe was involved in 11.1 per cent, the middle lobe in 4.9 per cent, and the lower lobe in 7.1 per cent. (The lateral situation in the upper lobes corresponds to the Boyden classification, B_3b, the posterior ramus of the posterior segmental bronchus, and to B_2A, the lateral subramus of the posterior branch of the anterior segmental bronchus, —or the "axillary" and "lateral" branches of Ewart. *Reviewer's note.*)

All axillary subsegments generally appear in the posteroanterior film as triangular opacities with the apices pointing toward the hilum and the bases in contact with the lateral thoracic wall. They are distinctly external and well separated superiorly from the apex and inferiorly from the diaphragm. They

have no connection, whatsoever, with the hilum. In the lateral view the densities appear to be triangular or quadrangular, clearly outlined, and centrally situated around the hilum.

The authors mention the special development of certain branches of the upper lobe bronchi into special axillary branches in roughly 15 per cent of cases. Such special development in the middle, lingular or lower lobes is much less frequent, but apparently occurs. Drawings from the diagrams of bronchial variations of the right upper lobe from Boyden's articles are reproduced.—*Chauncey N. Borman, M.D.*

Lambert, Robert L., Willauer, George, and Dasch, Frederick W. The postoperative status of the dependent lung. *J. Thoracic Surg.*, Dec., 1955, *30*, 713–718. (From: Eagleville Sanatorium, Eagleville, Pennsylvania.)

The authors studied the chests of 33 tuberculous patients immediately after chest surgery by means of roentgenograms made with the patients in various positions. The majority of their patients had surgery while in either the right or left lateral decubitus position. By maintaining this position for a few minutes after the completion of the surgical procedure and taking roentgenograms in the lateral decubitus position, a number of changes were present in the dependent, unoperated lung. These changes ranged from patchy infiltrations to complete homogeneous opacity of the dependent lung. There was marked clearing immediately after turning the patient into the supine position.

The authors suggest the roentgenographic abnormalities in the dependent lung may be due to three factors, compression from above downward by the weight of the mediastinal structures, elevation of the diaphragm by weight of abdominal contents and immobilization of the dependent hemithorax by weight of the patient's body. The net effect of these factors is probably to reduce the volume and movement of the dependent lung which favors stasis of blood, the accumulation of secretions and production of patchy atelectasis.—*Paul C. Olfelt, M.D.*

Grady, Roger C., and Zuelzer, Wolf W. Neonatal tuberculosis. *A.M.A. Am. J. Dis. Child.*, Oct., 1955, *90*, 381–391. (Address: Dr. Zuelzer, 5224 St. Antoine St., Detroit, Mich.)

Five fatal cases of tuberculosis occurring in the neonatal period are presented and correlated with autopsy findings.

All cases appear to represent acquired infection. Three infants were born of mothers who were undoubtedly ill at the time of delivery. Infection presumably occurred by aspiration during passage through the birth canal or during the short period of contact with the mother immediately following birth. In one instance, the infection was apparently acquired from the father and in another the source was unknown.

All of the cases showed evidence of extremely severe and widespread disease, characteristic of neonatal tuberculous infection. Prematurity was, in itself, thought to be an important contributing factor to the fatal outcome of these cases. In some, the lesions were anatomically distributed in a pattern typical of hematogenous infection, while the distribution of the intrathoracic lesions was typical of a primary tuberculous infection. Microscopic examination revealed multiple areas of necrosis with a relatively scant mononuclear-cell reaction. There was no evidence of giant-cell or tubercle formation seen, although the lesions were teeming with acid-fast organisms.

All 5 cases developed significant symptoms at six to eight weeks of age and, in most, acute symptoms followed a relatively asymptomatic period of what seemed to be normal growth and development. Only in retrospect were tendencies to thermal lability, occasional low-grade temperature elevations, intermittent periods of lethargy, and mild respiratory tract infections noted prior to the onset of acute symptoms. Thick nasal discharge, nonproductive cough, lethargy, low-grade fever, and some anorexia were among the commonest findings marking the onset of clinically obvious disease.

Tuberculin sensitivities in this group appear to be related to birth weight. While the term infant demonstrated a positive skin test at the onset of symptoms, this is not a consistent finding in a larger experience with term infants acquiring tuberculous infection. Chest roentgenograms were obtained in 4 of the patients, some of which had serial film studies. Many varieties of pulmonary lesions appeared which include upper lobe consolidation of a dense nature, cavitation, diffuse miliary type of infiltration with subsequent larger areas of consolidation. Tracheal narrowing and enlargement of the peritracheal and hilar lymph nodes were also seen. Some of the patients appeared to develop pulmonary emphysema in the more terminal stages of their disease.

A variety of therapeutic programs were followed, all of which appear to be obviously inadequate.—*James F. Martin, M.D.*

Hauser, Harry, and Glazer, Norman M. Coexistent tuberculosis and carcinoma of the lung. *Radiology*, Nov., 1955, *65*, 680–691. (Address: Dr. Hauser, 3395 Scranton Road, Cleveland, Ohio.)

The differential diagnosis of tuberculosis and carcinoma of the lung is often difficult from the roentgenologic standpoint. Even when tubercle bacilli are found in the sputum, one is still faced with

the problem as to whether concomitant carcinoma is present.

The authors report a study of 10 patients who had both tuberculosis and carcinoma. The roentgen findings in these patients were compared with those of 250 consecutive unselected cases of pulmonary tuberculosis, in order to determine in what aspects they differed.

The study indicates that carcinoma of the lung may be associated with tuberculosis if the following roentgen signs are present: a. unilateral prominence of the hilus; b. a hilar measurement (over-all length of both hili) exceeding 13 cm.; c. paratracheal lymph node enlargement; d. evidence of an atelectatic or collapsed lobe or segment, in which mottling, linear streaking and/or cavitation is not seen and the density is thus essentially homogeneous; e. a "spread of disease" in which the character of the infiltration is homogeneous, especially if it is in the lower lung fields; f. a nodular density greater than 3 cm. in diameter, especially if it is in the lower lung fields.

Although these signs may be present in tuberculosis, they are much more often noted in carcinoma of the lung, and such findings are an indication for further study to rule out concomitant disease.—*A. Ralph Watson, M.D.*

Skarbek, Andrew. Pulmonary cysts following ingestion of household paraffin. *Arch. Dis. Childhood*, Oct., 1955, *30*, 457–459. (From: North Cambridgeshire Hospital, Wisbech, England.)

The author presents an unusual case of a small boy who developed an acute pneumonia with multiple cystic cavities in the lungs after ingesting household paraffin or kerosene.

The history revealed the usual course of such a process following the ingestion of three-quarters of a one-pound jam jar filled with "Aladdin" pink paraffin. The patient then became acutely ill with a temperature of 102°F., pulse 140, and respirations of 45 per minute. The chest roentgenogram on the day of admission demonstrated bilateral pulmonary collapse affecting probably the right middle lobe, the lingula and both lower lobes. The patient responded to aureomycin and oxygen and at the end of two weeks the general condition was much improved. The roentgenogram taken fifteen days after admission showed a cavity in the right lung, at the site of the lower zone collapse in the previous roentgenograms. This was 4 cm. in diameter, the thickness of the wall being 4 mm. There was no fluid level. There was also a system of cavities in the middle and lower lobes of the left lung occupying the site of the former collapse. The chest roentgenogram on the eighteenth day after admission revealed a fluid level in the right basal cavity which a week later had shrunk to about 1 cm. in diameter. Subsequent roentgenograms showed a further reduction in the size of the cavity in the right lung, clearing of the lower zone of both lungs, and finally complete disappearance of the cystic spaces. A chest film made two months after admission showed some right basal collapse but no evidence of cystic change.

The author considered the roentgen appearance was caused by tension cyst formation rather than by destruction of lung tissue. This view was based on the rapidity with which recovery occurred and on the fact that no appreciable increase in the blood white cell count was found. The author believes that in the present case the reontgen appearance may have been a direct result of paraffin ingestion, or of secondary infection such as a staphylococcal infection. The latter supposition may be supported by the rapidity with which the condition subsided with antibiotics.—*James F. Martin, M.D.*

Rigler, Leo G., and Heitzman, E. Robert. Planigraphy in the differential diagnosis of the pulmonary nodule; with particular reference to the notch sign of malignancy. *Radiology*, Nov., 1955, *65*, 692–702. (Address: Dr. Rigler, University Hospitals, Minneapolis, Minn.)

The authors report the results of their studies to determine the value of laminagraphy in the differential diagnosis of isolated spheroidal shadows in the lung. Laminagrams of 132 patients exhibiting such nodules were reviewed. An attempt was made to evaluate the significance of marginal umbilication or notching of the tumor shadow. In 50 of the 132 cases the diagnosis was verified histologically. Of the proved cases, 24 were primary carcinomas of the lung.

Calcification in the nodule was best demonstrated by laminagraphy, and is regarded as clear indication of the non-malignant character of the lesion. Cavitation is strongly indicative of malignancy in this type of case. Cavities can often be demonstrated clearly by laminagraphy when they cannot be visualized clearly on conventional films.

Notching or umbilication of a border of a spheroidal nodule is described and offered as a new roentgen sign of malignancy. It is best demonstrated by laminagraphy. When present, it is highly indicative of malignancy, either primary or metastatic.

The notch may represent a sort of hilus indenting one surface. Since it can be on any portion of the surface of a spherical nodule, it may be hard to demonstrate. Failure to show this notching is therefore not to be regarded as an indication of an absence of malignancy.—*A. W. Sommer, M.D.*

Bessler, W. Propyliodon-Cilag-Suspension, ein neues Kontrastmittel für Bronchographie. (Propyliodon-Cilag-suspension, a new contrast medium for bronchography.) *Fort-*

schr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis, Oct., 1955, *83*, 553–559. (From: Röntgendiagnostisches Zentralinstitut der Universität, Zürich, Switzerland.)

The author had used dionosil (n-propyl ester of 3:5 diiodo-4-pyridone-n-acetic acid) which is suspended in a water medium. This substance dissolves poorly in water and only after being hydrolyzed by bronchial secretions is able to be absorbed. No iodine or iodides are released, so that there is no danger of iodine intoxication. The viscosity is low with the result that the material flows quickly into the alveoli and complete filling of the bronchi is unsatisfactory. A marked advantage of dionosil is its slight irritating effect on the bronchial mucosa.

For the past one-half year a new substance, propyliodon-Cilag-suspension, identical to dionosil but composed of finer and more homogeneous particles than dionosil, has been used in 100 bronchograms. This new substance has a higher viscosity and allows complete filling of the bronchial tree without the disturbing factor of filled alveoli. The irritating effect on the bronchial mucosa is similar to that of dionosil. Twenty to 30 cc. of propyliodon are used and because of its tendency to adhere to the mucosa, an excellent relief study of the bronchi can be obtained after expectoration of the injected material. Usually only a few bronchi can be made out twenty-four hours after the examination, and after seventy-two hours, the lungs are clear with no inflammatory changes noted. In isolated instances, inflammatory infiltrations due to the propyliodon were seen, which disappeared within a few days after antiobiotic treatment. In one-fourth of the patients, there was a rise in temperature of 1 to 2 degrees, usually on the day after the bronchography. The fever receded in two to three days. It is believed that the fever is not due to the injected material but to the associated disease in the lungs. There is no allergic reaction to the contrast material noted. The amount of anesthesia necessary was well below the toxic dose.—*Samuel Richman, M.D.*

Gombert, H. J., and Hoffmann, R. Propyliodon-Cilag, eine isotonische wässrige Kontrastmittelsuspension für die Bronchographie. (Propyliodon-Cilag, an isotonic, aqueous contrast medium suspension for bronchography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Oct., 1955, *83*, 559–562. (From: Röntgen- und Strahlenabteilung des Städtischen Krankenhauses Spandau und des Städtischen Krankenhauses Neukölln, Berlin, Germany.)

The disadvantages of oily iodine media in bronchography are: (1) failure of miscibility with the bronchial secretions, (2) tendency to produce droplets in the bronchi, (3) rapid filling of the alveoli, and (4) residual medium in the bronchi, often for years.

Most of the absorbable contrast media, except dionosil, because of their hypertonic characteristic, produce a marked irritation of the bronchial mucosa, necessitating an increase in the anesthetic dose.

The authors have used propyliodon-Cilag for six months and have found a minimal dose of local anesthetic satisfactory. This substance is an isotonic, aqueous contrast medium suspension, in which n-propylester of the 3:5-diiodio-4-pyridone-n-acetic acid is in micro-crystalline form in a 50 per cent concentration. The material adheres well to the bronchial walls giving an excellent outline of the mucosa. The resorption of this substance, which dissolves poorly in water but by action of the bronchial secretions is hydrolyzed without setting free any iodine, occurs slowly so that adequate fluoroscopic and roentgenographic examination may be done. Practically all of the material is eliminated in three to four days by the kidneys. Thirty bronchograms have been done without any disturbing side effects.—*Samuel Richman, M.D.*

Franzen, J., and Krupp, F. Röntgenologisch-klinische Differentialdiagnose raumbeschränkender Prozesse im vorderen Mediastinum: Cyste oder Aneurysma? (Roentgenologic-clinical differential diagnosis of space-occupying processes in anterior mediastinum: Cyst or aneurysm?) *Thoraxchirurgie*, Oct., 1955, *3*, 227–235. (From: Röntgeninstitut und Medizinische Klinik der Johannes-Gutenberg-Universität, Langenbeckstrasse 1, Mainz, Germany.)

In the differential diagnosis of mediastinal lesions, the location or origin as well as the contour of the shadow and its relation to the neighboring structures, are the most significant points. Laminagraphy, angiography, etc., including radioactive iodine administration for detecting thyroid tumors have all been used at times.

The authors report a case of a fifty-three year old female who complained of increasing difficulty in breathing. The patient was markedly cachetic. The chest was symmetrical, with marked flatness over left side. A systolic murmur was heard over all the valves of the heart. The blood pressure was 145/90.

A chest film taken one year before admission showed moderate degree of elevation of the right diaphragm. An oval-shaped mass extending to the left of midline more to the left than to the right was seen in anterior and middle mediastinum. This mass was homogeneous in density and had convex borders, with the transverse greater than the vertical diameter. The heart was widened but the aorta could not be identified. The film taken on admission no longer showed the left border of the mass. In upper left lung were numerous areas of decreased density,

believed to represent bronchiectasis. The trachea and esophagus were displaced ot the left and posteriorly. No pulsations could be made out. The right diaphragm was elevated as before. The bony thorax was normal. Laminagraphy confirmed the presence of bronchiectasis and revealed calcifications in the mass, collapse of left lower lobe, and irregular contour on the right.

Based on the above findings, it was believed that the patient had a mediastinal lobulated mass. Since the Wassermann reaction was negative and the heart not enlarged, an aneurysm of the aorta was considered less likely than a neoplasm. Unexplained was the blockage of the left upper bronchus with resulting bronchiectasis, collapse of left lower lobe, and paresis of right phrenic nerve (elevated diaphragm).

Autopsy showed a false aneurysm of the ascending aorta the size of a "child's head," and an extensively calcified capsule in the anterior mediastinum and left chest. There was a thin point of rupture just above the aortic valves and extending for 4 cm. into the aortic arch. The left lung was compressed and had bronchiectasis. The pathologist believed that the tear in the aorta was traumatic in origin. Later, it was ascertained that thirty-one years earlier the patient did have an injury to the sternum. In the literature, paralysis of the phrenic nerve occurs frequently in the presence of an aortic aneurysm, but never in a dermoid cyst or teratoma. Most traumatic aortic aneurysms lead to immediate death.—*Samuel Richman, M.D.*

Seaman, William B., and Goldring, David. Coarctation of the aorta with patent ductus arteriosus. *J. Pediat.*, Nov., 1955, *47*, 588–598. (From: Edward Mallinckrodt Institute of Radiology and Department of Pediatrics, Washington University School of Medicine, St. Louis, Missouri.)

The authors suggest use of a classification of coarctation based on anatomic and hemodynamic considerations and on the adequacy of the collateral circulation. They present 12 cases of coarctation with patent ducts arteriosus. All cases were proved by surgery or autopsy.

The reported case of coarctation distal to the patent ductus showed enlargement of the right ventricle out of proportion to the other chambers and pulmonary hypertension with engorgement of the pulmonary vessels. The lesion is compatible with long life. Retrograde angiography showed the obstruction of the aorta and flow of the contrast medium from the aorta into the pulmonary artery apparently through a patent ductus. The lesions are amenable to surgery.

In the reported cases of coarctation of the aorta proximal to the patent ductus, there were two significant roentgen findings. These were moderate to marked enlargement of the right ventricle and dilatation and engorgement of the pulmonary vessels. The angiocardiogram usually will show opacification of the right heart, pulmonary artery and the descending aorta (via the patent ductus). The brachiocephalic vessels are not filled at this time.

Two of the 4 patients subjected to angiography died soon after the prodecure was done. It is recommended that this examination be reserved for those in which there is a reasonable doubt about the diagnosis. The angiographic studies usually afford excellent confirmatory evidence.—*Frank M. Windrow, M.D.*

Brown, J. W., Heath, D., and Whitaker, W. Cardioaortic fistula; a case diagnosed in life and treated surgically. *Circulation*, Nov., 1955, *12*, 819–826. (From: Regional Cardiovascular Centre, City General Hospital and The University Department of Medicine, Royal Hospital, Sheffield, England.)

A case of aneurysm of a sinus of Valsalva which ruptured into the right ventricle is decribed. The case was diagnosed during life and the diagnostic features are presented.

The patient was a seventeen year old girl seen as an emergency case in January, 1953, with symptoms of fever (103°F.) and a loud precordial systolic murmur which at times became continuous. She had been seen at the age of nine years for the same murmur, which was detected during a routine school examination and diagnosed as patent ductus. Blood culture showed streptococcus viridans. The fever promptly subsided with penicillin therapy.

The cardiac lesion was then investigated. The important findings were: blood pressure, 140/0, slight cardiac enlargement, left ventricular hypertrophy by electrocardiogram, faint but definite reopacification of pulmonary arteries at seven seconds by angiocardiography and abnormally high oxygenation of blood in outflow of right ventricle with normal low oxygenation of blood in the right auricle. The high pulse pressure along with high oxygenation of blood in the right ventricle and the murmur indicate left-to-right shunt above aortic valve and into the right ventricle instead of into the pulmonary artery.

Corrective surgery was refused by the girl's parents. She returned with a Staphylococcus aureus septicemia and endocarditis seventeen months later and did not respond to any antibiotic. The fistula was closed surgically but the patient died fourteen days later with multiple visceral abscesses. Autopsy showed the aneurysm of the right and posterior sinuses of Valsalva which had ruptured, forming a fistula into the right ventricle just above the anterior cusp of the tricuspid valve. Vegetations were present on the aortic valves and Staphylococcus aureus was cultured from them. The other valves were normal.

Apparently the aneurysm had been present many years and probably ruptured during the first febrile episode. Usually there is severe chest pain, intense breathlessness, nausea and vomiting with such rupture. This patient had none of these symptoms so that it is possible that the fistula was congenital.

The diagnostic signs suggested are: (1) murmur; (2) high pulse pressure; (3) high oxygenation of blood in right ventricle, especially the outflow tract; and (4) reopacification of pulmonary artery late in the cardiac cycle during angiocardiography.—*Frank M. Windrow, M.D.*

Nahon, Joseph R. Roentgenologic characteristics of the epipericardial fat pad, with a case report. *Radiology*, Nov., 1955, *65*, 745–748. (Address: Veterans Administration Hospital, East Orange, N. J.)

A large right-sided epipericardial fat pad frequently presents a smoothly rounded or lobulated shadow of soft-tissue density filling the cardiophrenic angle as seen on the posteroanterior film. The differential diagnosis of such a shadow should include pericardial cyst, localized pericardial and paraspinal effusions, eventration, anomalies and tumors of the diaphragm, bronchogenic neoplasm, metastatic neoplasm, cardiospasm, atelectasis, cardiac aneurysm or neoplasm, mediastinal dermoid, neurofibrosarcoma, subpleural tuberculoma, and tracheobronchial cyst. The roentgenogram in the lateral view usually shows a faintly visualized triangular shadow filling the anterior costophrenic angle and superimposed upon the antero-inferior aspect of the heart.

The author presents a case report of a patient being investigated and treated for tuberculous disease in the right upper lung field. Lateral laminagraphy demonstrated well the pericardial fat pad which was proved at subsequent surgery for the tuberculous lesion.—*Donald N. Dysart, M.D.*

Abdomen

Swyer, Paul R. Partial thoracic stomach and esophageal hiatus hernia in infancy and childhood. *A.M.A. Am. J. Dis. Child.*, Oct., 1955, *90*, 421–451. (From: Department of Paediatrics, University of Toronto and Hospital for Sick Children, Toronto, Canada.)

The author has made a comprehensive review of the literature covering hiatus hernia of the stomach and it complications. He had paid particular attention to reports of such conditions in children, and evaluated them in comparison with over 100 cases followed for years by Waterston at the Hospital for Sick Children, Great Ormond Street, London, and with 18 cases examined by himself during eighteen months at the Hospital for Sick Children, Toronto.

One of the author's 18 cases is considered to be an example of undoubted shortness of the esophagus, which is a rare anomaly. In the other 17 patients shortening of the esophagus proved to be apparent only or was due to muscular or fibrous retraction in association with esophagitis.

The author elaborates on the classification of hiatus hernia proposed by Åkerlund (*Acta radiol.*, 1926, *6*, 322). The most common type is the sliding hiatal hernia. The rolling parasophageal hiatus hernia is rare in childhood. A third variety combines the features of sliding and paraesophageal rolling hernias. A further possible explanation for the presence of gastric mucosa above the diaphragm is the suggestion of Allison (*Thorax*, 1953, *8*, 87–101) that following erosion by reflux, repair may occur through upward extension of gastric mucosa.

In a review of 1,177 cases of hiatus herniation at all ages the incidence of esophagitis was reported as 43 per cent, and of stricture 17.7 per cent. The author believes these figures are higher than the true incidences, since most published reports emanate largely from surgeons in adult clinics, who are more likely to see complicated cases.

Among the author's 17 patients the diagnosis was made under the age of one year in fifteen. The earliest diagnosis was made at four days by esophagoscopy. No sex trend was evident in this series, but other authors have found a significant preponderance of females over males.

Vomiting was a constant finding in the author's series. In some cases wasting and anemia were also evident. In 13 of the 17 patients, the hemoglobin content was less than 11 gm. per 100 cc.; although in one, the anemia was due to a coincidental erythroblastosis fetalis. The author suggests that ill humor and intractability in infants may be manifestations of the same distress which in older children and adults produce complaints of pain behind the lower sternum and dysphagia.

Although the first requisite in diagnosing the condition is clinical suspicion, confirmation is by roentgenology. The examination of infants and children should always be in the horizontal position. An initial swallow of a thick bolus of barium will often be more informative than the use of a thin suspension, which, however, is necessary afterward to obtain filling of the stomach. The supradiaphragmatic pouch is sometimes filled best with a rise in intra-abdominal pressure such as occurs on crying or with external pressure on the abdomen. The detection of esophagitis by the roentgen examination is very difficult, and suspicion of such should be checked with the esophagoscope. Because in some cases the herniation is intermittent, or reflux is not produced at the diaphragmatic hiatus, a negative roentgenologic result in the presence of a suggestive history should be treated with some reserve, and the investigation repeated.

Aspiration pneumonitis is the principal complica-

tion in infants who regurgitate. Acute obstruction by impaction of food particles, and periesophagitis are additional hazards.

Postural treatment, consisting of keeping the child in an upright position or suspending him on an inclined mattress, usually results in marked symptomatic improvement. Thickening of the child's feedings further tends to discourage reflux. If after a few weeks of conservative treatment vomiting continues the case should be reassessed. If esophagoscopy shows continuing esophagitis, operation should be advised to forestall stricture formation. Cases which develop strictures may sometimes be treated satisfactorily by dilatation alone, but in many instances operative repair of the hernias should be carried out first. When the stricture is severe some form of plastic procedure, with resection of the acid-bearing portion of the stomach, is frequently necessary. Paraesophageal hernias should all be repaired because of the added risks of volvulus, incarceration, and ulceration. The author prefers the thoracic approach to repair over the abdominal, and states that infants and children stand thoracotomy extremely well.—*Arthur S. Tucker, M.D.*

Torres, Luciano M. Prolapso de la mucosa gástrica. Acción de los anticolinérgicos. (Prolapse of the gastric mucosa; effects of the anticholinergic drugs.) *An. de cir.*, April–June, 1955, *20*, 156–162. (From: Instituto de Cirugía, "Sanatorio Britanico," Rosario, Argentina.)

Excellent results have been obtained in 8 patients with prolapse of the gastric mucosa into the duodenal bulb by means of antrenyl, (diethylaminoethylic ester of the phenolhexihydroxiacetic acid). Treatment was started in all cases with intramuscular injection of 10 mg. of antrenyl followed by a maintenance dosage of 30–40 mg. daily. The clinical picture improved promptly. Disappearance of the characteristic findings on fluoroscopy was frequently observed twenty minutes after the parenteral dose had been administered.—*F. Comas, M.D.*

Ochsner, Seymour, and Ochsner, Alton. Sarcoma of the stomach; analysis of 17 cases. *Ann. Surg.*, Nov., 1955, *142*, 804–809. (From: Departments of Radiology and Surgery, Ochsner Clinic, New Orleans, La.)

The authors present an analysis of 17 cases of sarcoma of the stomach.

Sarcomas comprise 5.7 per cent of all gastric malignancies. The lymphomas in their series showed a wide variety of roentgenologic appearances, suggesting fungating and infiltrating carcinomas, benign, and malignant gastric ulcerations, giant mucosal hypertrophy and obstruction of the gastric outlet. Leiomyosarcomas, on the other hand, showed a more characteristic roentgenologic appearance, usually having a smooth filling defect with a central ulceration. There were 10 lymphomas, 6 leiomyosarcomas, and 1 neurofibrosarcoma in the series.

The authors recommend surgical excision for all sarcomas even though this may have to be bold in massive lesions. They believe that postoperative irradiation is definitely indicated in the lymphoma group, including the cases in which the tumor may have been completely removed.—*C. L. Hinkel, M.D.*

Camp, Walter H. Carcinoid of the stomach. *Radiology*, Nov., 1955, *65*, 753–754. (Address: 281 N. Kingsboro Ave., Gloversville, N. Y.)

The differential diagnosis of circumscribed filling defects in the stomach usually includes such benign lesions as leiomyoma, adenomatous polyp, aberrant pancreatic tissue and lipoma.

The author presents a case report including the roentgenographic findings of a carcinoid of the stomach. This patient had epigastric symptoms including melena which led to surgery.

Since a review of the literature revealed only 10 cases with symptoms leading to operation and few published roentgenograms the author felt that this condition should be called to the attention of radiologists.—*Donald N. Dysart, M.D.*

Acquaroni, Banilo. Divertículos duodenais; considerações gerais. (Duodenal diverticula; general considerations.) *Rev. med. e cir. de São Paulo*, July, 1955, *15*, 17–45. (From: Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil.)

This paper is based on 6 observations of duodenal diverticulum (4 of them operated) and on additional 69 cases, collected from the Brazilian literature. The incidence of this condition varies between 0.1 and 6 per cent among patients with gastrointestinal disease.

Duodenal diverticular are *true* (wall containing all layers of the intestine) or *false* (muscular layer absent); *primary* (seldom located in the first portion of the duodenum) or *secondary* (postulcerous, called pseudodiverticula in the English literature, usually found in the first portion). Among the 75 cases, 20 per cent were in the first portion of the duodenum, 48 per cent in the second, 19 per cent in the third, and 13 per cent in the fourth.

Diverticula are said to develop in a weak spot on the duodenal wall, in the presence of increased intraluminal pressure. The fragility of the wall may be due to (1) pancreatic rests, (2) traction by biliary or pancreatic ducts, (3) place of penetration of vessels into the muscular layer, etc.

At autopsy, the diverticula are usually empty, while during surgery they are often filled with food and/or detritus. Microscopically, the mucosa is neat (except when inflamed), with a well developed

muscularis mucosae; the muscular layer is thick at the diverticular mouth, but thinned out over the fundus.

The symptomatology is nonspecific (nausea, diarrhea, eructations, weight loss, etc.), and may simulate other conditions (dyspeptic, pseudo-ulcerous, pyloro- or duodeno-stenotic, hepato-biliary, pancreatic). Barium meal study is the most important examination, as it will determine the presence, location, and size of the diverticulum. Oblique spot films (for posterior location), various maneuvers (graded compression, contrast material instilled through catheter, Trendelenburg position), and progress views (configuration, food content, evacuation time) will furnish additional information. When diverticulitis supervenes, the outline becomes irregular, and there is tenderness on pressure during roentgenoscopy.

Among the complications mentioned are *diverticulitis* (due to or causing stasis), *hemorrhage* (sometimes due to associated ulcer), *icterus* (by obstruction of the common duct), *acute pancreatitis* (by obstruction of Wirsung's canal), *peridiverticulitis* (with subsequent adhesions to colon, or other organs), and the exceedingly rare *neoplastic degeneration*.

Asymptomatic duodenal diverticula (incidental roentgen finding) need no therapy. When complaints are present, patient must be evaluated for possible surgery, perhaps after a conservative treatment trial. There should be a complete workup to rule out adjacent (gastric, hepatic, pancreatic) pathology. Imperative surgical indications are perforated diverticulum (peritonitis!), prolonged and/or repeated hemorrhage, and suspected neoplastic degeneration (constant intradiverticular filling defect). When in doubt, operation may be suggested in the presence of (1) retention of barium in the diverticulum longer than six hours after ingestion (stasis) and (2) pain and slight wall rigidity on pressure over the right lower epigastric region.—*E. R. N. Grigg, M.D.*

Davies, Orland, Johansen, Robert, and Goldman, Leon. Reversed rotation of the bowel causing acute intestinal obstruction. *Ann. Surg.*, Nov., 1955, *142*, 875–880. (From: Department of Surgery, University of California School of Medicine, San Francisco, Calif., and University of California Surgical Service, San Francisco Hospital, San Francisco, Calif.)

The authors review 31 cases of reversed rotation of the intestine and report 1 of their own. The patient was operated upon for intestinal obstruction and recovered following resection of the right colon.

Normally about the tenth week of intra-uterine life, the proximal intestine, which is supplied by the superior mesenteric artery, rotates counter-clockwise 270° into its normal position. In reversed rotation of the bowel, however, the midgut rotates clockwise 90° permitting the transverse colon to pass dorsal to the superior mesenteric artery. When this occurs the duodenojejunal junction lies anterior to the transverse colon. The anatomic condition is prone to cause: (a) obstruction of the transverse colon due to compression by the superior mesenteric vessels, (b) volvulus of the right colon or (c) duodenal jejunal obstruction. The diagnosis has apparently been established only at operation or necropsy.—*C. L. Hinkel, M.D.*

Beirne, Michael F. Malignant melanoma of the small intestine. *Radiology*, Nov., 1955, *65*, 749–752. (Address: U.S.A. Hospital, Fort Sill, Okla.)

Thirty-three malignant melanomas of the gastrointestinal tract have been described in the literature. Of these, 22 were definitely metastatic lesions, while the exact nature of some of the others remains in doubt.

The author presents a case of malignant melanoma in which the lesions were found upon roentgen examination and at surgery to be scattered throughout the small bowel in the form of multiple polypoid tumor growths. These tumors varied from pink to black in color, and 2 to 28 mm. in size. Microscopic examination established a diagnosis of malignant melanoma. This diagnosis was confirmed by the Armed Forces Institute of Pathology.

A careful search for a primary melanoma was conducted, but no such lesion could be found, so it was presumed that the primary focus was to be found in the small intestine. No autopsy was obtained.—*A. Ralph Watson, M.D.*

Arrieta Sánchez, L. Un signo radiográfico más en las obstrucciones del ileon terminal. (One more roentgenographic sign in obstruction of the terminal ileum.) *Radiología, Panama*, June, 1955, *5*, 87–94. (From: Hospital Santo Tomas, Panama, Republic of Panama.)

For several years the author has noted an interesting sign in upright films of some patients with symptoms of an acute abdominal process. This sign consists of one or two gas-distended loops of small intestines seen in the form of the letter "U," which may be seen inverted or with the branches a little open so as to simulate the arc of a circle. These loops may be seen in the left upper quadrant or in mid-abdomen.

Six cases selected from over 40 patients seen the past two years are presented to demonstrate the sign.—*Charles M. Nice, Jr., M.D.*

Maddison, T. G., and Hyde, I. Chronic regional enteritis in childhood. *Arch. Dis. Child-*

hood, Oct., 1955, *30*, 469–471. (From: Children's Hospital, Birmingham, England.)

Although not uncommon in adults, chronic regional enteritis in children has been infrequently reported. The use of ACTH has been instituted in a few cases with promising results. The authors report a case of a ten year old boy who had been ill for twelve months with an enteritis which by reontgenographic examination involved the cecum and terminal few inches of ileum. During seventeen days in the hospital on supportive therapy he continued to lose ground. He was then started on ACTH, 40 units a day, and improved to the point where, after eighteen days of medication, he passed a normal, formed stool. The dosage of ACTH was reduced but continued for a total period of eighty days, giving the boy 2,145 units altogether. Five weeks after the cessation of ACTH a barium enema study revealed suggestion of healing, although there still was narrowing of the cecum and terminal ileum. For five months after the ACTH the boy remained in complete remission, but then suffered a return of symptoms. He was then given oral cortisone, which resulted in a moderate but distinct improvement, but not the dramatic remission which had previously occurred.

The authors report a second case of regional enteritis, in a boy of twelve years. His distal ileum was resected, with satisfactory results.

They suggest that ACTH is worthy of a trial in a child suffering from chronic regional enteritis before surgery is contemplated.—*Kriss M. Kerr, M.D.*

Fowweather, F. S. True enteroliths of the small intestine; with report of three cases. *Brit. M. J.*, Oct. 22, 1955, *2*, 1010–1012. (From: Department of Chemical Pathology, University of Leeds, Leeds, England.)

Three cases of true enteroliths found in the small intestine are presented. In one case 9 separate stones were found interspersed between constricted areas in the terminal ileum. Another had 4 stones impacted in a blind ileal loop, and a third case had a large black stone impacted at the ileocecal valve. Most of the stones had a nidus of a small plum or fruit stone. It seems likely that the sharp points of plum stones may cause trauma, swelling or spasm which will result in the slow passage of the stone or a definite arrest giving ample opportunity for the deposition on them of insoluble material producing true enteroliths.

A stricture or diverticulum of the small intestine is regarded necessary for the formation of stones. A suitable nucleus must also be present. The composition varies between bile acid, calcium oxalate, and phosphate. Organic matter is usually present. Bile acid enteroliths are more apt to be precipitated in the proximal parts of the small bowel, while phosphate enteroliths precipitate in the more alkaline distal segments. Calcium oxalate stones may occur anywhere if mechanical factors are conducive.—*Arch H. Hall, M.D.*

Hodgson, John R., and Kennedy, Roger L. J. The roentgenologic aspects of chronic ulcerative colitis in children. *Radiology*, Nov., 1955, *65*, 671–679. (From: The Sections of Roentgenology and Pediatrics, Mayo Clinic and Mayo Foundation, Rochester, Minn.)

One hundred twenty-two cases of idiopathic chronic ulcerative colitis in children seen at the Mayo Clinic between January, 1944, and January, 1954, are reviewed with particular attention to the roentgenologic aspects of the condition. It was found that the disease occurs almost twice as often among boys as among girls and it occurs with increasing frequency up to fifteen years of age.

Diagnosis depends on correlation of clinical, proctoscopic, and roentgenologic information, with the proctosigmoidoscopic examination and the roentgenologic study being of equal value. Clinically, bloody diarrhea is characteristic of the disease and, with few exceptions, is present in every case. Proctoscopic examination in the typical case reveals an edematous reddened mucosa which bleeds easily when touched. The roentgenologic manifestations are the same in children as in adults. The roentgen findings in moderately advanced chronic ulcerative colitis are narrowing and shortening of the bowel, thickening of the wall, polypoid hyperplasia, and destruction of the mucous membrane. In early or minimal involvement the mucous membrane may appear fuzzy and feathery or it may have a jagged, serrated, sawtooth appearance. In 96 per cent of the series the entire colon was involved and there was involvement of the terminal portion of the ileum in at least 16 cases.

Changes in the bowel evident on roentgenologic examination are more marked in children from ten to fifteen years of age and complications are more frequent in this age group. Complications include peritonitis, extracolonic abscesses and sinus tracts developing from submucosal extension of abscesses occurring near the surface of the mucous membrane which enlarge and perforate. Pseudopolyps due to hypertrophy of islands of mucosa left in the colon after acute ulceration had subsided were present in 25 cases. These are readily demonstrated roentgenographically and must be watched carefully since they may become carcinomatous and may be an indication for colectomy.—*Harold C. Hamilton, M.D.*

Beranbaum, Samuel L., and Subbarao, Kakarla. Morphological study of abdominal gas shadows. *Am. J. Digest. Dis.*, Oct., 1955, *22*, 281–287. (From: Department of Radiology, University Hospital of the New York Uni-

versity, Bellevue Medical Center, 303 E. 20th St., New York, N. Y.)

The authors point out that in roentgenologic-evaluation of intra-abdominal viscera, the gas which is ordinarily present in the intestinal tract may provide a useful contrast for morphologic study in abnormal conditions.

The paper which contains very little discussion is composed almost entirely of roentgenograms illustrating how perusal of the gas shadows within the abdomen may reveal evidence of intrusional masses (such as carcinoma of the stomach), persistent incisura in the stomach (associated with ulcer or tumor), or extrinsic defects (such as appendiceal abscess, etc.).—*C. L. Hinkel, M.D.*

Sandweiss, David J., and Fulton, Harold. Intravenous cholangiography; results in one hundred cholecystectomized patients with upper abdominal symptoms. *J.A.M.A.*, Nov. 5, 1955, *159*, 998–1001. (Address: Dr. Sandweiss, 9739 Dexter Blvd., Detroit, Mich.)

The authors studied roentgenologically 100 cholecystectomized patients who experienced moderate to severe epigastric and/or right upper quadrant distress that simulated biliary tract disease. Of these patients, 90 had gallstones at time of cholecystectomy. The intravenous contrast medium, sodium iodipamide (cholografin) was used.

The patients were prepared as for cholecystography. A preliminary roentgenogram was made of the right upper abdomen, and following a sensitivity test, 20 to 40 cc. of the medium was injected intravenously at a slow rate. Films were made of the right upper abdomen at the conclusion of the injection and at ten minute intervals for a period of one hour. The diameter of the common duct was measured directly on the films and 8 mm. was selected as an arbitrary upper limit for normal.

The common duct and hepatic radicles were visualized in ninety-four (94 per cent) of the 100 cases. In 5 cases which the common duct did not visualize there was impairment of liver function as evidenced by chemical tests. Excluding duplications, thirty-four (36 per cent) of the 94 patients showed normal cholangiograms; 7 patients (7 per cent) showed stones in the common duct, and 3 patients (3 per cent) showed dilated cystic duct stumps. This group of 44 patients had clearly positive or negative findings; in the remaining 49 patients (53 per cent) the roentgen findings were equivocal. Of these, 25 patients had unexplained dilatation of the common duct and 24 patients had common ducts of apparently normal width, but the terminal end of the duct was not visualized.

Of the 30 patients with dilated ducts, 4 (13 per cent) showed definite stones on the cholangiograms. Of the 64 with ducts of normal width, 3 (5 per cent) showed stones. The significance of a dilated common duct with visualization of a stone is not clear. The amount of dilatation is apparently not related to the time interval since cholecystectomy.

Nonvisualization of the terminal end of the common duct, a critical area, is one of the limitations of the examination as well as lack of visualization of the biliary tree in the presence of jaundice and impaired liver function.—*William C. Strittmatter, M.D.*

Leupold, F., and Heuck, F. Untersuchungen über die Anwendung der neuen Gallekontrastmittel bei Gesunden und Leberkranken. (Studies concerning the use of the new biliary contrast medium in the normal and in liver diseases.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Oct., 1955, *83*, 464–470. (From: Medizinische Universitätsklinik, Kiel, Germany.)

According to several investigators the use of biligrafin is contraindicated when liver damage is present. (The new drug is known as cholografin in the United States.) It has been reported that in 8 out of 23 patients with liver disease, in whom bile ducts could not be visualized, a marked shift of serum protein fractions was found with increase of the alpha and beta globulins.

In a group of 15 cases the authors have made the following tests before and again three to six days following the cholografin injection: (1) Takata Ara, (2) thymol, (3) bilirubin, (4) alkaline phosphatase and (5) serum cholesterol. In this series the tests have failed to disclose any liver damage. Only in 1 case did a previously negative Takata reaction become positive, while in 2 other cases this reaction changed from positive to negative following cholografin injection. Changes of bilirubin and phosphatase were no more pronounced following the injection than could be expected normally in the course of the disease.

The injection was well tolerated in a group of 320 cases. Only in 1 case with liver disease did a collapse occur two minutes after the injection. The blood pressure became so low that it could no longer be recorded. In spite of aggressive therapy improvement occurred only after four to five hours. There was no allergy, and liver tests were normal before and after the injection.

Optimal filling of the bile ducts was seen thirty minutes after the cholografin injection in cases with and without previous cholecystectomy. A visualization which was delayed beyond forty minutes was considered normal only when overweight patients received too small a dose, but suggested liver damage in all other cases. An overdose of cholografin resulted in renal excretion in the beginning in spite of normal liver function. A moderate degree of liver opacification was frequently observed, but was absent when the drug was excreted rapidly. Nonvisualization of the gallbladder and bile ducts

did not rule out hepatic excretion altogether but suggested the possibility of low concentration of the contrast material. In such instances the opaque material could sometimes be detected in the duodenum or jejunum.

Abnormal serum protein fractions did not interfere with the liver excretion, and a normal excretion occurred repeatedly in spite of suspected liver damage according to symptoms, the Takata reaction and the thymol test. There was no definite connection between abnormal bilirubin values and liver function. A delayed or absent liver excretion, however, was noted in cases with increased phosphatase and in cholesterinemia.

When the liver function is too poor, the drug will be excreted by normally functioning kidneys instead. The only contraindication to the use of chologrāfin exists when various tests reveal poor kidney function as well as liver damage in the same case.—*Ernest Kraft, M.D.*

Feine, U. Erfahrungen bei der intravenösen Cholangiozystographie mit Biligrafin. (Experiences with the intravenous biligrafin cholangiocystography.) *Forstchr. a. d. Geb. d. Röntgenstrahleu ver. m. Röntgenpraxis*, Oct., 1955, *83*, 445–464. (Address: Max-Peanck-Inst. f. Biophysik, Forsthausstr. 70, Frankfurt a M., Germany.)

The author's experience with biligrafin (known as chôlografin in United States is based on 450 cases including 53 postcholecystectomy cases. The following indications for the intravenous method have been formulated: (1) Nonvisualization or equivocal findings with the oral method; (2) strong suspicion of pathologic changes of the biliary system; (3) faulty absorption of the oral medium by the gastrointestinal tract; (4) desirability of demonstrating the bile ducts.

The intravenous method has never been proved harmful. There are no definite contraindications to its use, but it has been considered with hesitancy in acute cholangitis, congestive failure, chronic jaundice and marked liver damage. Visualization of the biliary system has been possible in 90 per cent of cases.

For the diagnosis of gallbladder disease the intravenous method has the following advantages over the oral method: (1) The gallbladder can be more frequently visualized even when pathologic changes are far advanced; (2) when the gallbladder cannot be visualized, but the medium is excreted by the liver, a diagnosis of advanced cholecystitis and lithiasis can be established; (3) diagnosis of chronic cholecystitis is made probable when the oral method reveals only faint visualization while the intravenous method discloses good filling; (4) diagnosis of cholecystoptosis with poor fixation of gallbladder in liver bed can be established.

For the diagnosis of bile duct changes the following standards of measurement have been established: The hepatic duct has an average width of 3.9 mm., while the common bile duct is normally 4 to 6 mm. wide. A duct measuring more than 7 mm. in width is considered to be dilated. Visualization of the smaller branches of the hepatic duct suggests always a stenosis further down toward the common duct. Total occlusion of the common duct with stagnation of bile prevents visualization of the biliary system. In such instances the drug is excreted by the kidneys instead of the liver. Physiologic renal excretion of an overflow of the drug, however, occurs frequently in the beginning, even in normal cases.

The postcholecystectomy group consisted of 47 cases with 54 examinations. The bile ducts in this group could be visualized in 91 per cent with evidence of dilatation in 60 per cent.

Of the total group there were 40 cases with absent or faint visualization, 13 with severe liver damage, 21 with marked icterus and one cardiac case with congestive failure. In two additional cases with cardiac failure, however, visualization was normal.

The intravenous method with chologrāfin has proved to be a dependable liver function test. Although not helpful in all cases, it has never caused any damage. Nonvisualization denotes either liver damage or obstructive jaundice.

Cholangiocystography is useless in chronic icterus with serum bilirubin values over 6 mg. per cent. When feces are acholic, liver excretion is practically absent. Visualization is also improbable in hepatic and cholangitic cirrhosis and in marked liver enlargement due to metastatic tumors.

The author concludes that chologrāfin examination is far superior to other methods. Bile ducts can now be visualized in 98 per cent of cases with normal liver excretion. Dilatation of bile ducts can be detected in 50 per cent of all pathologic cases. The lengthy article contains many details, tables and reproductions of excellent roentgenograms.—*Ernest Kraft, M.D.*

Bergareche, J. (San Sebastián, Spain.) La acción colelitoquinética del lipiodol. (The cholekinetic effect of lipiodol.) *Bol. Inst. Pat. Méd.*, Sept., 1955, *10*, 161–164.

In persistent bile drainage after operations on the gallbladder a cholangiogram with lipiodol not only frequently gives the clue to the cause of impaired bile flow to the duodenum but occasionally it may also act as a therapeutic agent. The author has observed this action over many years, attributing it to the soothing effect of the oil on the sphincter of Oddi and to its emulsifying properties on the biliary gravel.

The present communication refers to a case of common duct obstruction by a gallbladder stone. The patient had had a cholecystostomy for acute purulent cholecystitis, a biliary fistula ensuing six weeks after operation. A first cholangiogram with lipiodol showed a stone in the common duct. Reoperation was decided upon ten weeks later because

of deterioration of her general condition and copious biliary drainage. However, hours after a second cholangiogram had been performed as part of the preoperative work up, all symptoms of common duct obstruction subsided and another subsequent cholangiogram revealed free passage of bile to the intestine.

The author does not accept the contention that lipiodol has cholekinetic or stone dissolving properties, but believes its effects are due to relaxation of the smooth muscle fiber of the sphincter of Oddi.—*F. Comas, M.D.*

Carroll, David S. Annular pancreas. *South M. J.*, Dec., 1955, *48*, 1270–1277. (From: Department of Radiology, College of Medicine, University of Tennessee, Memphis, Tenn., and the City of Memphis Hospitals, Memphis, Tenn.)

Five cases of annular pancreas with preoperative roentgen studies of the upper gastrointestinal tract are reported. All showed the findings described by other authors who have encountered instances of this anomaly—dilatation of the proximal portion of the duodenum and an abrupt, smooth, concentric narrowing of the descending duodenum with rather marked but incomplete obstruction.—*George Cooper, Jr., M.D.*

Sanford, Clarence E. Annular pancreas as a surgical problem. *A.M.A. Arch. Surg.*, Dec., 1955, *71*, 915–926. (From: Department of Surgery, Millard Fillmore Hospital, Buffalo, N. Y.)

The problem of annular pancreas is discussed from both diagnostic and therapeutic points of view by reviewing 72 case reports collected from the literature up to 1954, and an additional case from the author's experience. This total is made up of 35 pediatric cases and 38 adults, in all of which the accuracy of preoperative diagnosis is given as 12 per cent.

The disease is manifested by obstructive type symptoms in the neonatal period, delayed ulcer-like symptoms occurring in adulthood or without symptoms at all, the lesion being discovered incidentally at necropsy. In an infant with clinical evidence of high partial obstruction, roentgen examination may lead to the proper explanation. The plain films may outline gas contained within the stomach and separated by the pylorus from a distended duodenal cap with no gas visible beyond, the so-called "double-bubble" sign. Barium studies may verify this by showing notching, stenosis, or obstruction in the second portion of the duodenum with distention proximally and alterations in emptying time. In the adult, this picture may be complicated by the fact that peptic ulcer may be associated with this lesion in about a third of the group and associated deformities particularly when in the duodenal cap may be misleading. In any case, the anomaly must be considered and searched for or it may easily be misdiagnosed.

Therapeutically, the two age groups present different problems. Duodenojejunostomy appears to be the preferred operation in the infant. In the adult group the author recommends subtotal gastric resection, warning that section of the ring often fails to relieve symptoms and may be complicated by pancreatic fistula.—*James A. Martin, M.D.*

Cook, Glenwood L. Radiographic diagnosis of carcinoma of head of pancreas. *South. M. J.*, Dec., 1955, *48*, 1277–1280. (From: Department of Radiology, Jones County Community Hospital, Laurel, Miss.)

In a patient with a large carcinoma of the head of the pancreas, excretory pyelography demonstrated a thinned out right renal pelvis and obliteration of the calyces. Chamberlin and Imber reported similar changes in the left kidney demonstrated by excretory pyelography in 6 patients with carcinoma of the tail of the pancreas. The changes are assumed to represent the result of direct pressure upon the kidney. When found in the presence of other evidence, suggestive of pancreatic malignancy, the findings support that diagnosis, but are not conclusive because renal or nearby tumors other than pancreatic could produce similar changes.—*George Cooper, Jr., M.D.*

Hershey, John E., and Hillman, Frederick J. Fatal pancreatic necrosis following choledochotomy and cholangiography; report of a case. *A.M.A. Arch. Surg.*, Dec., 1955, *71*, 885–889. (From: Department of Surgery, University of Washington School of Medicine, and Veterans Administration Hospital, Seattle, Wash.)

The authors present the case of a postoperative death occurring in a 39 year old male following elective cholecystectomy, choledochotomy, and operative cholangiography. At operation, a thick walled gallbladder was found to contain many small stones and the common duct was also thick walled and edematous in association with a small sphincter of Oddi. Fifteen cc. of 35 per cent iodopyracet (diodrast) was injected through the T tube for each of two examinations and films demonstrated complete filling of the duct of Wirsung and the accessory pancreatic duct as well as the biliary tree. Although the operation was somewhat prolonged, it was otherwise uneventful and the patient's condition was considered satisfactory until twelve hours later when he developed shock. He remained profoundly ill for six days and died in convulsions. Essential findings at autopsy were acute pancreatic necrosis with extensive fat necrosis and fatty infiltration of the liver.

In considering an explanation, it is noted that the patient exhibited no reaction to sodium iodomethamate (neo-iopax) given intravenously for pyelograms prior to surgery and that hypersensitivity to

the iodopyracet probably was not a factor. Instead it is suggested that reflux injection of the pancreatic duct with a possible pressure exceeding normal physiologic biliary pressure may well have produced pancreatic damage at the time of surgery. This thesis is somewhat supported by the fact that rather large volumes of opaque medium were employed in the presence of a spastic or stenotic sphincter of Oddi, and that the pancreatic duct was found to join the common duct proximal to the sphincter. The authors further postulate possible increased pancreatic sensitivity to damage secondary to a protein deficiency as suggested by the presence of fatty changes in the liver. As a result of this experience, it is advised that operative cholangiography be performed with careful attention to volume of opaque medium employed and the pressure under which it is injected.—*James A. Martin, M.D.*

Hessén, Ingemar. Roentgen examination in cases of occlusion of the mesenteric vessels. *Acta radiol.*, Oct., 1955, *44*, 293–305. (From: Roentgen Department, University Hospital, Uppsala, Sweden.)

Vascular occlusion of the mesenteric vessels is a relatively rare condition, difficult to diagnose and with a high degree of mortality. Trotter compiled 359 cases, with the correct diagnosis made in only 13 cases.

Occlusions usually occur in the superior mesenteric artery or vein which handles the circulation for the entire small intestine, the ascending colon and proximal half of the transverse colon. Occlusions are rare in the inferior mesenteric artery and vein. Frimann-Dahl reporting on 17 cases believes that vascular occlusion generally causes dilatation of the intestinal area supplied by the obstructed vessel. Dilatation may also occur proximal to an intestinal infarct due to the fact that the affected area causes a relative obstruction to the lumen of the bowel. Thus the picture may be similar to mechanical ileus. Fluid levels may be present and paresis of the intestine is the rule in most cases.

The author's material consists of 20 cases. On all except one, operation or autopsy or both were performed. In 18 cases the occlusion commenced in the superior mesenteric artery or vein, in the two remaining cases the site of initiation was the ileocolic artery. A summary of the case reports reveals *negative* roentgen signs in 5 cases, with gas formed only in stomach and colon. *Uncharacteristic* roentgen signs occurred in 6 cases, with one or two loops of small intestine containing gas. The loops were not distended and a fluid level was found in only one case. *Positive* roentgen signs occurred in 9 cases, consisting of intestinal dilatation caused by a more or less marked obstruction of the lumen, either mechanical or paretic in character, accompanied by gas and fluid fillling of the intestine. Not all cases showed fluid levels. In some cases the infarcted area was dilated, in others the main distention was above the point of infarction. The time that roentgen signs appeared varied greatly in relation to the time when the patient fell ill. The lengthiest cases have been those of venous thrombosis. The only change which may be considered typical of vascular mesenteric occlusion is local paresis of the small intestine. However, a discrepancy between clinical signs which indicate a serious, acute, abdominal condition and negative or uncharacteristic roentgen signs should arouse a suspicion of vascular mesenteric occlusion.—*Arthur B. Smith, M.D.*

Gynecology and Obstetrics

Posner, A. Charles, Bloch, Norman R., and Posner, Norman S. The flat sacrum: Its importance in obstetrics. *Am. J. Obst. & Gynec.*, Nov., 1955, *70*, 1021–1025. (From: Department of Obstetrics of the Bronx Hospital, New York, N. Y.)

The flat sacrum presents several problems to the obstetrician. It may be associated with various types of pelvic contractions. The anteroposterior pelvic diameters may be contracted when the flat sacrum inclines forward. The transverse pelvic diameters are often found shortened as the funnel-type pelvis is frequently found associated with the flat sacrum.

A five-year review is presented of 12,787 deliveries with 2,068 roentgen pelvimetric examinations in which flat sacra were demonstrated. Increased incidence of operative delivery is suggested in the flat-sacrum group. Increased incidence of breech presentation was found in the flat-sacrum group. Labor was prolonged in 40.2 per cent of the group. The problem of occiput transverse arrest in the mid-pelvis and the effect of the flat sacrum are discussed. In a series of 440 patients with flat sacra, the cesarean section incidence was 17.7 per cent as contrasted to a cesarean section incidence of 4.9 per cent for all deliveries.—*Eugene J. McDonald, M.D.*

Gerosa, Horacio N., and Malenchini, Manuel. Histerosalpingografías con soluciones acuosas. (Hysterosalpingography with aqueous solutions.) *Prensa méd. argent.*, June 10, 1955, *42*, 1701–1708. (Address: Dr. Malenchini, Montevideo 1612, Buenos Aires, Argentina.)

After having experimented with several contrast media to obtain hysterosalpingographies, the authors have become convinced that the aqueous solutions of iodine compounds without added substances to increase their viscosity render the best results. The intra-uterine injection is easily and painlessly performed; the contrast obtained on the films is as good as with any other substance; it flows without any

difficulty even through very narrow tubes. The time required for visualization of the genital tract is short, enabling the radiologist to check the passage and deposition of the contrast medium into the peritoneal cavity. Another further advantage is that the iodine compound is promptly absorbed and with its elimination by the kidneys it serves as a descending pyelogram.—*F. Comas, M.D.*

Abrams, Bernard S., and Hughes, Anson. Pneumocography as an aid in the diagnosis of gynecologic disease. *Am. J. Obst. & Gynec.*, Nov., 1955, *70*, 1115–1125. (Address: Dr. Abrams, 10300 Carnegie, Cleveland 6, Ohio.)

One hundred and sixty-one cases of transabdominal pneumoperitoneum are evaluated and indications and contraindications to pneumoperitoneum as a diagnostic procedure are discussed. The limitations of pneumoperitoneum are outlined, with emphasis on the utilization of this procedure only when indicated, as an aid in diagnosis.

The diagnostic procedure of pneumoperitoneum adequately demonstrates pelvic disease. It is especially effective for ovarian cysts, adnexal tumors, and subserous fibroids. Tubo-ovarian masses secondary to pelvic inflammatory disease can seldom be adequately visualized by pneumocography for these are usually bound down to the surrounding structures and cannot be outlined by the carbon dioxide. By the same token, tumors filling the pelvis cannot be demonstrated. In such cases pneumocography is unnecessary for diagnosis.

Adhesions between the intestine and pelvic organs are easily demonstrated. This may be of benefit when patients are evaluated preoperatively to determine by what route the uterus should be removed. Many operators feel that, should adhesions be present, the abdominal approach is to be preferred.

The authors believe that teaching institutions should include in their gynecologic training program the essentials of pneumoperitoneum, and should familiarize the residents with an acceptable technique of performing this type of examination. Each graduate should know how to use pneumocography as a diagnostic procedure, realizing its indications and limitations.—*Eugene J. McDonald, M.D.*

Genitourinary System

Hutch, John A., Bunge, Raymond G., and Flocks, Rubin H. Vesicoureteral reflux in children. *J. Urol.*, Nov., 1955, *74*, 607–620. (Address: Dr. Hutch, 2100 Monument Blvd., Pleasant Hill, Calif.)

This is a study of 8 children who had persistent vesicoureteral reflux with hydroureter and hydronephrosis of varying degree. These patients had symptoms of recurring episodes of the urinary tract infection and kidney pain.

The operation which is used has been described previously by these authors. Briefly, it consists of an attempt to increase the length of the intravesical segment of the ureter. This is accomplished by dissecting the intramural ureter from its attachment to the bladder wall except at the trigone. After this is done, a 2 cm. segment of ureter is pulled into the bladder and the defect in the bladder wall caused by the dissection of the intramural ureter is sutured under the newly created intravesical ureter.

A detailed case history of the 8 patients included in this study is given, and there are 31 roentgenograms of these patients.

The authors describe three methods by which ureteral reflux is prevented due to the action of the ureterovesical junction. First, as the bladder becomes distended, the position of the intravesical ureter is such that pressure is applied and compresses the roof of the intravesical ureter against its floor. Second, as a result of the contraction of the longitudinal fibers of the intravesical ureter, there is a sharp upward pulling of the ureteral orifice after each spurt of urine through it, and the lumen of the orifice is actively occluded by contraction of its walls. Third, the downward pull of the ureteral orifice by the contraction of the trigone during micturition increases the length of the intravesical segment of the ureter and this closes the lumen of this segment of the ureter.

Any disease or condition which interferes with the dynamic relationship between the bladder wall on one hand, and the intravesical ureter and trigone on the other is apt to result in ureteral reflux. It is with these facts in mind that the authors had advised the operation which they describe.

This operation has been shown to effectively stop reflux as demonstrated by the delayed cystogram which consisted of three to four films over a period of one to two hours. Each patient has had two to three such examinations each year since surgery. Clinically, the patients have shown improvement; however, in 2 patients the pyelographic improvement, which occurred following operation and lasted for a period of two and one half years, has not continued. These patients now show further dilatation and, in 1 instance, a nephrostomy was necessary. Poor results were observed in the patients who had a meningomyelocele.—*George W. Chamberlin, M.D.*

Berry, Carl D., Jr., and Cross, Roland R., Jr. Use of bag ureteral catheters for nephrograms: Obstructive nephrograms. *J. Urol.*, Nov., 1955, *74*, 683–692. (Address: Dr. Berry, 406 Chicago Ave., Oak Park, Ill.; Dr. Cross, 952 N. Michigan Ave., Chicago, Ill.)

The renal parenchyma can be increased in density for roentgenologic purposes by either one of two methods. One of these is by concentration of contrast media in the vascular network of the kidneys

and is seen following aortography or rapid injection of concentrated iodine preparations followed by prompt roentgen exposure. This method has the disadvantage of extremely short duration. The second method is based upon the concentration of contrast media in the tubules of the kidney. In the presence of acute ureteral obstruction, the intrarenal pressure may reach a level at which the glomerular filtration is suppressed. This suppression of glomerular filtration does not interfere with the elaboration of the iodine containing compounds by the renal tubules.

The authors block the lower ureters by a small inflated rubber bag attached to the ureteral catheter. A no. 5 F radiopaque ureteral catheter with a filiform tip is used. A thin latex sheath approximately 1.5 cm. in length is fitted over the hole near the tip of the catheter and secured to the catheter at either end with fine silk. A 24 F Brown-Buerger cystoscope will allow two bag catheters to be passed to the ureters. These catheters are inserted into the cystoscope in a retrograde manner so as to avoid tearing the latex rubber bag. The catheters are inserted well into the abdominal portion of the ureter and the cystoscope is then removed leaving the catheters in place. The rubber bag is inflated by slowly injecting 0.5 cc. of skiodan and it is then clamped with a hemostat. A survey film is then taken to demonstrate the opaque medium in the ureteral bag and the patient is allowed to wait fifteen minutes before the intravenous radiopaque medium is injected. This will allow a column of urine to collect above the point of the obstruction and fill the upper collecting system. Films are made following the intravenous injection at fifteen minute intervals. In most cases the nephrograms are of excellent quality in forty-five or sixty minutes after the injection. The sharpest nephrograms were obtained when using bilateral ureteral obstruction; however, unilateral obstruction on the side in which the parenchymal visualization is desired will also give good results in instances where the opposite ureter cannot be catheterized.

The authors have used this method in 14 patients and obtained good results in 10. Failures were chiefly due to difficulty in maintaining inflation of the obstructing bags.

This method has the distinct advantage of allowing sufficient time for adequate roentgen studies of the kidneys in various positions. The technique is simple and requires no special equipment or training. The procedure is usually well tolerated by the patient.—*George W. Chamberlin, M.D.*

Billion, H., and Schlungbaum, W. Über die Verteilung von radioaktivem Perabrodil M im menschlichen Organismus und seine Anwendung in der Nieren-Clearance. (On the distribution of radioactive perabrodil M in the human body and its use for kidney clearance test.) *Klin. Wchnschr.*, Dec. 1, 1955, *32*, 1089–1093. (From: Strahleninstitut der Freien Universität Berlin am Städtischen Krankenhaus Westend, Berlin, Germany.)

A clearance test consists of introduction into the body of a special substance, with subsequent determination of its volumetric excretion in function of time; the data thus obtained permit evaluation of the renal function. The special substance used in this series was perabrodil (iodopyracet) M, tagged by incorporation of radioactive iodine. The measurements were compared with a clearance test performed with *p*-aminohippuric acid, which is also eliminated by filtration in the glomeruli, and active additional secretion (concentration) in the tubules: this explains the fast excretion of both substances.

The activity of the various perabrodil M preparations was about 20 microcuries (this figure is not further qualified in the text); the biological half-life in plasma reached six minutes after 200-400 mg. perabrodil, eight minutes after 2,250 mg. perabrodil. Biochemical procedures are given in detail, including the determination of plasma concentration. The clearance value can be obtained from the formula

$$\text{Clearance (cc./min.)} = \frac{\text{Urine concentration (\%/liter)} \times \text{Urine volume(cc./min.)}}{\text{Serum concentration (\%/liter)}}$$

In 7 patients without clinical evidence of kidney dysfunction, the clearance figures varied between 313 and 875 cc./min., which compares well with the results obtained by Davies and Shock with diodrast. An eighth patient, known to have severe chronic glomerulonephritis, cleared only 34 cc./min.

The authors recommend the radio-iodopyracet renal clearance test for its accuracy and speed (about one hour total determination time from ingestion, as compared with four hours for *p*-aminohippuric acid).—*E. R. N. Grigg, M.D.*

Nervous System

MacCarty, W. C., Jr., and Lane, F. W., Jr. Pitfalls of myelography. *Radiology*, Nov., 1955, *65*, 663–670. (Address: Dr. MacCarty, Hitchcock Clinic, Hanover, N. H.)

Since myelography is a procedure being employed more frequently the authors reviewed 400 consecutive cases in which the examination had been done in order to evaluate its accuracy. This report is based on 223 patients who were operated upon as they permitted correlation between the myelographic findings and the anatomic diagnosis.

Ruptured intervertebral disk was found in 81.2 per cent while 8.5 per cent had a tumor of the spinal cord, meninges or extradural tissues. Two and seven-tenths per cent had myelographic abnormalities due to hypertrophic changes, and vascular anomalies such as epidural varices or enlarged veins accounted for 3.6 per cent. Arachnoiditis, congenital anomaly and trauma were found in 1.8 per cent. No abnor-

mality was discovered in 2.2 per cent to account for the myelographic finding. Involvement of more than one intervertebral space by protruded intervertebral disks was found in 12.5 per cent. An over-all accuracy of 89.3 per cent was found for myelography compared with an accuracy of 61.3 per cent clinically.

The pitfalls which accounted for the errors in diagnosis are analyzed in order that they can be avoided in future examinations. Pantopaque is the medium of choice for all examinations except when the thoracic region is thought to be the site of the lesion. In this case lipiodol should be employed. The use of an adequate amount of medium, usually about 6 cc., is necessary to prevent overlooking small lesions. Removal of as much of the medium as possible after the procedure decreases unpleasant aftereffects of myelography.

The site of needle insertion should always be at a distance from the area to be investigated in order to prevent defects from the needle itself from confusing the picture. The authors advise delaying myelography for at least a week after a diagnostic spinal tap since the leakage of cerebrospinal fluid into the subdural space may cause significant defects in the opaque medium at the time of examination. Subdural and extradural injection of the medium results from inaccurate placement of the needle and leads to a typical irregular distribution which does not allow accurate diagnosis. Because of the possibility of multiple disk involvement or multiple spinal cord tumor, the subarachnoid space should always be scanned from the cul-de-sac to the midthoracic region.

A consistent manner of reporting should be adopted by the radiologist in order to avoid miscalculation of the level of the lesion when vertebral anomalies are present. Normal variations in size and shape of the subarachnoid space may cause errors. A narrow opaque column 16 mm. or less in width may not demonstrate a laterally located herniated disk. A wide subarachnoid space may show posterior bulges of the annulus fibrosus. A narrow tapering cul-de-sac may not demonstrate a low level herniated disk and also a short cul-de-sac will not permit localizing a lesion below it. Previous myelography, laminectomy, spinal anesthesia or even a diagnostic lumbar puncture may cause confusing defects due to adhesions and scarring.

An adequate number of films made before the examination, during fluoroscopy, and after fluoroscopy with the medium still in place, will help avoid errors of omission and inadequate localization. A fluoroscopic table which permits smooth tilting to 90° in the caudal direction and at least 45° Trendelenburg position greatly facilitates accurate myelography.—*Donald N. Dysart, M.D.*

Nathan, Lester A., and Matheson, Abe. Toxoplasmosis in infants; report of two cases. *J. Pediat.*, Nov., 1955, *47*, 640–644. (From: Sarah Morris Hospital for Children of the Michael Reese Hospital, Chicago, Ill.)

The authors report 2 instances of toxoplasmosis in infants and children. One patient survived to the age of three months and expired suddenly from a convulsion. The other has been followed to her twenty-second year of life and the pertinent clinical data are reported.

The pathology of toxoplasmosis in infants generally consists of granulomatous type lesions and areas of necrosis in the brain and spinal cord. These areas frequently become calcified and harbor the parasite. In adults an infection with toxoplasma frequently becomes generalized, whereas in infants and children it is recognized chiefly in the central nervous system.

In early life, clinical symptoms may be predominantly neurological, such as convulsive seizures, retraction of the head and stiff neck. Shortly after birth an internal hydrocephalus of the obstructive type may develop. Spasticity, opisthotonus, or paralysis may also be demonstrated on physical examination. Chorioretinitis with focal areas of involvement has been described. Less specific complaints such as feeding problems, vomiting, diarrhea, and upper respiratory infections may be present. The cerebrospinal fluid most frequently gives an increased amount of protein and may be xanthochromic.

Roentgen examination of the skull in both instances revealed intracerebral calcification. Ventriculography showed marked generalized dilatation of the entire ventricular system through the third ventricle.

The authors present a discussion of the Sabin dye test for diagnosis, and include a brief note in regard to present day therapy in which daraprim along with the sulfanilamides show some promise.—*James F. Martin, M.D.*

Skeletal System

Kammerer, Th., Mathis, M., and Wackenheim, A. A propos d'une forme incomplète de gargoylisme; intérêt diagnostique de la ponction biopsie du foie. (An incomplete form of gargoylism; diagnostic importance of puncture biopsy of the liver.) *Presse méd.*, Oct. 19, 1955, *63*, 1386–1389. (From: Clinique Psychiatrique, Strasbourg, France.)

Detailed description of the clinical and laboratory findings of a mentally retarded girl of eight years of age presenting all the major characteristics of Hurler's syndrome, except the corneal opacification, is given. Analyzing the world literature on this rare syndrome, the authors favor the term used by the American authors, i.e. lipochondrodystrophy (which underlines the lipoid metabolic abnormality as a pathogenesis) over the term dysostosis multiplex

(based on anatomic abnormalities) as used by the German authors. Hence, they think that a puncture biopsy of the liver is an important diagnostic method in proving gargoylism in vivo, since in some cases the clinical and laboratory findings are not complete. In order of frequency, the four major characteristics of this syndrome are: 1) Anomaly of the skull, gargoyle appearance of a long head over a short neck (97.9 per cent); 2) mental retardation (83 per cent, 3) hepatosplenomegaly (63.5 per cent), 4) corneal opacification (59.5 per cent).

Roentgenographic findings are important. There is increase in vertical diameter of the skull, enlargement and exaggeration of the diploic markings, hyperostosis of the posterior part of cranial vault, premature closure of the sutures and defective pneumatization of the mastoid air cells, and in case of hydrocephaly, considerable thinning of the vault.

The vertebrae show a hammer deformity because of shortening of the superior anterior portions of the hemivertebrae. The long bones are short and wide and show an exaggeration of the normal physiologic torsion. The ribs show widening resembling a palm branch or oar.

Puncture biopsy of liver of the case of the authors, where there was hepatosplenomegaly, revealed intra- and extracellular steatosis. Such a steatosis is not pathognomonic yet is indicative of the lipoid metabolic disturbance underlying this syndrome.—*J. N. Sarian, M.D.*

Prowler, Joseph R., and Smith, Ernest W. Dental bone changes occurring in sickle-cell diseases and abnormal hemoglobin traits. *Radiology*, Nov., 1955, *65*, 762–769. (Address: Dr. Prowler, 3700th Air Force Hospital, Lackland Air Force Base, San Antonio, Texas.)

This study was undertaken in order to present observations concerning the roentgenographic appearance of the dental bones of persons who had some form of sicklemia or the abnormal hemoglobin C, D, E, or G traits.

The findings in these bones consisted mainly of areas of radiolucency of varying size and degree and extent of involvement. Every instance of sickle-cell anemia in this study showed moderately severe or severe changes while the more mild sickle-cell variant disorders showed only minor changes. It is felt by the authors that the presence of severe dental bone changes is at least suggestive of sickle-cell anemia and that the finding of only minimal roentgenographic changes makes the presence of this disease unlikely.

Another finding encountered in this study was the presence of one, two or three discrete rounded areas of increased density seen in the base of the bone of the mandible or the maxilla. These have sharply defined margins, are round or oval, and have no relation to periodontal structures. They are thought to be due to healed infarcts.

The authors briefly discuss these diseases and their diagnosis and conclude with the statement that dental roentgenograms may be of considerable value in detecting individuals with hemoglobin abnormalities.—*Donald N. Dysart, M.D.*

Friedman, Jack, and Goldner, Meyer Z. Discography in evaluation of lumbar disk lesions. *Radiology*, Nov., 1955, *65*, 653–662. (From: Departments of Radiology and Orthopedic Surgery of Mount Sinai Hospital, Minneapolis, and University of Minnesota, Minneapolis, Minn.)

The authors present an analysis of the findings in 150 patients with back pain who were studied by means of discography. It was performed only on those patients with long-standing, severe, incapacitating back pain in whom surgical intervention was thought necessary and clinical localization or myelography was inadequate. Their technique of discography was based upon that of Lindblom. Fluoroscopy was employed to assure proper direction of the fine needle into the disk. In this manner excessive probing and unnecessary puncture of the subarachnoid sac was avoided.

An attempt was made to inject three spaces in each patient. In 50 of the 150 cases studied, pantopaque myelography was also performed. In only 14 of these did the myelogram and discogram agree completely as to the negative or positive findings; in 22 cases there was complete disagreement. Disk operations were done on 96 of the 150 patients for whom discograms were obtained. There were no cases in which disks interpreted at discography as offending were found to be negative on exploration.

Discography was found to be more reliable than myelography for the discovery of intervertebral disk degeneration. Reproduction of pain upon injection of the contrast medium proved to be an accurate sign of the offending nature of the disk.—*A. W. Sommer, M.D.*

Blood and Lymph System

Hoffmann, G. R., Chabeau, P., and Lemahieu, S. F. L'angiographie carotidienne dans les tumerus cérébrales. (Carotid angiography in cerebral tumors.) *J. belge de radiol.*, 1955, *38*, 113–166. (From: Services de Neurochirurgie, Institut St-Vincent, Gand, et Hôpital St-Jean, Bruges, Service de Radiologie, Institut St-Vincent, Gand, and Service de Neuroradiologie, Hôpital St-Jean, Bruges, Belgium.)

This is an extensive treatise on the use of carotid angiography in the diagnosis of cerebral tumors. The history of the development of carotid angiog-

raphy is presented briefly. If percutaneous injection is not immediately successful a small incision is made between the two portions of the sternocleidomastoid muscle to facilitate injection of the common carotid artery. The anatomic features of the intracranial arteries and veins filled by carotid injection are described and illustrated. The significance of displaced vessels and the formation of tumor vessels and arteriovenous anastomoses are all documented. Several cases are presented and illustrated to demonstrate the vascular displacements of neoplasms in various locations and of the vascular paterns of various types of tumors of the middle and anterior portions of the skull.—*Charles M. Nice, Jr., M.D.*

Lin, Paul M., and Scott, Michael. Collateral circulation of the external carotid artery and the internal artery through the ophthalmic artery in cases of internal carotid artery thrombosis; report of five cases. *Radiology*, Nov., 1955, *65*, 755–761. (Address: Dr. Lin, Temple University School of Medicine, Broad and Ontario Streets, Philadelphia, Penna.)

In occlusion of the internal carotid artery the defective cerebral circulation can be improved by collateral circulation through the circle of Willis. If this circulation is inadequate, due to underdevelopment of the anterior and the posterior communicating arteries, collateral circulation can be established through anastomosis of the branches of the external carotid artery with the ophthalmic artery, the middle meningeal artery, or muscular branches of the vertebral artery. Angiographic demonstration of collateral circulation of the latter type, in the absence of filling of the internal carotid artery above the bifurcation of the common carotid artery, is described as a pathognomonic sign of occlusion of the internal carotid artery.

Five cases of internal carotid artery occlusion in which a definite diagnosis was established by angiographic demonstration of anastomosis of the external carotid artery and the internal carotid artery above the site of occlusion through retrograde circulation in the ophthalmic artery of the same side are presented. This retrograde filling of the ophthalmic artery appears in the late arterial phase of carotid angiography, usually two to four seconds after the injection of the contrast medium.—*Harold C. Hamilton, M.D.*

Sutherland, D. L., Kite, William C., Jr., Roach, J. F., and Campbell, Eldridge. A note on the use of 25 per cent iodopyracet (Diodrast) in cerebral angiography. *J. Neurosurg.*, May, 1955, *12*, 223–225. (From: Departments of Surgery and Radiology, Albany Medical College, Albany, N. Y.)

The authors have previously reported an incidence of 11.5 per cent minor and 4.3 per cent major sequelae following the use of 35 per cent iodopyracet (diodrast) in cerebral angiography.

This report concerns their experience with 25 per cent iodopyracet in 108 consecutive cerebral and vertebral angiographies utilizing 30 to 40 cc. of media. Patients ranged from eighteen to fifty-six years of age.

The major and minor complications were reduced to 2 per cent with the use of the 25 per cent solution. No significant difference in the delineation of pathologic changes was apparent as compared with the 35 per cent solution. It was apparent in the 25 per cent group that the roentgen density of the vessels as they traversed the base of the skull was not as great as one might have desired.—*J. A. Campbell, M.D.*

Eiseman, B., and Rainer, W. G. A new technique for thoracic aortography using the right supraclavicular approach. *A.M.A. Arch. Surg.*, Dec., 1955, *71*, 859–862. (From: Department of Surgery, University of Colorado School of Medicine, and Denver Veterans Administration Hospital, Denver, Colo.)

This paper presents a new method for thoracic aortography, utilizing a right supraclavicular approach. It is simpler than retrograde arterial injection and is done under local anesthesia. The patient is placed on his back with the head turned to the left and a film taken of the thorax. After proper preparation and draping of the right cervical and supraclavicular regions, a skin wheal with 1 per cent procaine hydrochloride is raised in the mid-clavicular line 1 cm. above the clavicle. A no. 17 15.4 cm. aortogram needle fitted with a stylet is inserted through the skin wheal and directed medially, inferiorly and slightly posteriorly, aiming at a point 3 cm. below the jugular notch in the mid-sternal line. At this point the needle meets the apex of the aortic arch at its broadest point and enters the lumen in the direction of blood flow. In this way the danger of perfusing the coronary system is alleviated. The needle may cross the apex of the right pleura but should not impale the lung; however, it is advisable not to withdraw the stylet until the needle is in the aorta to avoid producing a pneumothorax. After puncture of the aorta 30 cc. of 70 per cent urokon is injected as rapidly as possible with a 50 cc. Luer-Lok syringe and the films are taken as the last of the medium leaves the syringe.

The authors have to date employed this technique on 4 patients without difficulty. They state that the only subjective sensation is a dull substernal discomfort as the needle passes through the wall of the aorta. Their illustrations show the thoracic aorta well visualized from the arch to the diaphragm.—*Arthur B. Smith, M.D.*

Lodin, Herman. Lumbar aortography in acute aortic embolism. *Acta radiol.*, Oct., 1955, *44*, 289–292. (From: Roentgen Department, University Hospital, Uppsala, Sweden.)

Acute total occlusion of the aorta constitutes an absolute indication for operation. Accurate diagnosis is of utmost importance to avoid unnecessary operative interference. Without aortography one cannot determine whether the occlusion is complete or at what level the upper limit of the occlusion is in the aorta. Aortography cannot show the lower limit of the occlusion, but the author feels that from the point of view of surgery, aortography is indicated in every case of acute aortic embolism.

The risks of lumbar aortography in these patients are considerable. The usual cause of aortic embolism is a fibrillating dilated left auricle in mitral stenosis or cardiac infarction. The use of the prone position and light NO_2-ether anesthesia produced no ill effects in any of the four patients examined.

When the aortic occlusion is complete the injection entails a considerable risk of momentary overloading of the kidneys with contrast medium, as the latter is dammed up and remains longer than usual in the aorta. Both the volume and concentration of contrast medium should therefore be less than for ordinary aortography and the injection is made manually, at low pressure. The aorta is punctured in the usual way, 20–25 cc. of umbradil 50 per cent or 35 per cent is injected and the roentgen exposure made at the time when increased resistance due to the occlusion is felt. Physiologic saline is then injected to dilute the contrast medium in the aorta, the needle is removed and the patient turned onto his back.

In three cases the defect in the contrast filling showed an upward convexity typical of a recent embolus, while in the 4th case the border was straight. Two patients recovered after embolectomy and had uneventful postoperative courses. The other two expired.—*Arthur B. Smith, M.D.*

Mériel, P., Ruffié, R., Fournié, A., Baux, R., Bastide, G., and Gaubert, J. La phlébographie de la hanche. (Phlebography of the hip.) *Presse méd.*, Oct. 19, 1955, *63*, 1381–1383. (From: Clinique Médicale du Prof. Mériel, Centre de Rhumatologie, Toulouse, France.)

This paper is based upon 100 cases of phlebography of normal and pathological hips. Normal venous drainage of the hip is discussed and diagrammatically illustrated. The principal veins of the hip are the deep gluteal, posterior cervical, obturator, capsular and circumflex veins.

The technique of the authors consists in injecting under local anesthesia, diodone (35 per cent) through 12 to 15 caliber needles into the greater trochanter, which is very easy to locate. Sometimes the neck of the femur, which is hard to locate, is used for injection. The radiopaque solution is injected slowly into the medullary spaces after slight aspiration of blood into the syringe. The amount of pain and difficulty of injection are in direct relation to the venous return capacity of the hip area. Hence, these two criteria are already of importance as to information of the venous circulation. The pain is caused by an intraosseous distention as the opaque medium is injected. The authors think of controlling the pain and the pressure used during injection with a constant caliber needle of equal quantities of diodone by means of a dynamometer, various pressures being necessary for injection of hips in different pathologic states.

Besides the pain, which is of diagnostic value, as described above, the only other inconvenience is a slight and transient elevation of temperature within twenty-four hours.

When normal and pathologic hips were injected and phlebograms compared, it was noted that the main venous return channels were poorly visualized in the pathologic cases, where there was definite tendency for the opaque medium to flow below the level of the injection point. Also, the pathologic hips showed numerous small accessory venous channels, in a way to compensate for the normal venous channels. The medullary spaces seemed to fill unduly in case of abnormal hips. From the dynamic point of view, more pressure was needed to inject the opaque medium into the intramedullary spaces in case of pathologic hips, and hence a longer time was required. Thus it took 30 seconds to inject 15 cc. of the opaque medium into normal hips, whereas in arthritic hips the time of injection was above one minute, and almost two minutes. Sometimes it was even impossible to inject the opaque medium.

The authors conclude that the venous drainage of osteoarthritic hips is definitely hampered and poor, and that the disturbance lies mainly in the medullary venous drainage and secondarily in the articular capsule venous return. This latter usually is quite well taken care of by a collateral venous circulation. The venous return handicap is more important in the primary osteoarthrosis of the hip than in the secondary (to trauma or congenital deformity) coxarthrosis. This fact leads them to think that probably a poor venous system is one of the main causes of arthrosis of the hips.

Several fine phlebograms of normal and pathological hips are reproduced.—*J. N. Sarian, M.D.*

Campeti, Frank, Gramiak, Raymond, Watson, James S., Ramsey, George H., and Weinberg, Sydney. Visualization of the coronary sinus in cineangiocardiography. *Circulation*, Aug., 1955, *12*, 199–206. (From:

Department of Radiology, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.)

In 25 of the 100 most recent cases examined by means of cineangiography, reflux opacification of the coronary sinus was observed. It occurred in atrial systole in all cases and, in a few instances, continued into diastole. In two thirds of instances, there was associated reflux into the inferior vena cava. The latter sometimes occurred in systole and sometimes in diastole.

Visualization of the coronary sinus is clearest in the left anterior oblique projection but can also be distinguished in the right anterior oblique projection when filling extended as far as the great cardiac vein. The movements of the sinus are closely related to those of the atrioventricular septum, taking place on a diagonal path.

Of the 25 cases exhibiting reflux, 88 per cent had cardiovascular anomalies known to be associated with severe right heart hypertension. Twelve of these cases were catheterized and in all but one there was severe hypertension of one or both right heart chambers. Of the remaining 75 cases, only 32 per cent had lesions which would produce right sided hypertension. Nineteen were catheterized and hypertension found only in 9.

The authors feel that the reflux is not a physiologic phenomenon although not enough evidence is available. In 18 patients with apparently normal circulation reflux was not seen. Neither do they feel that the reflux is caused by unphysiologic increased intra-atrial pressure resulting from rapid injection since the valvular mechanism should protect the sinus. This theory is partially supported by the observation of degeneration of the atrial venous septum in chronic valvular disease and the finding that the coronary orifice is consistently enlarged in the diffusely dilated hearts of those with clinical congestive heart failure.

The conclusion is therefore reached that the reflex is of diagnostic significance and whenever present, right atrial and right ventricular hypertension should be looked for. This is of particular importance in pulmonary stenosis where the angiogram may be otherwise not unusual.—*Myer Sharpe, M.D.*

Read, John L., Bosher, Lewis H., Ferraru, Felix, Richman, Samuel, and Porter, Reno R. Angiocardiographic demonstration of occlusive auricular thrombi in dogs. *Circulation*, Aug., 1955, *12*, 247–249. (From: Cardiovascular Section of Medical Service, Thoracic Surgery Section of Surgical Service, and Radiology Service of Veterans Administration Hospital, and Cardiovascular Surgery Division of Department of Surgery and Cardiovascular Division of Department of Medicine, Medical College of Virginia, Richmond, Va.)

Simulated occlusive thrombi of the left auricle were created surgically in 6 dogs by invaginating the left auricular appendage. Angiocardiographies were performed on 5 of the dogs and, in each instance, a clear cut filling defect was demonstrated. Since occlusive thrombi of the left auricle occur in 1 of 8 autopsied cases of mitral stenosis and in 1 of 10 cases in the authors' series, it is believed that angiocardiography would be of considerable value in demonstrating such thrombi in appropriate human patients, especially as an aid in the selection of patients for mitral surgery.—*Myer Sharpe, M.D.*

General

Lequime, J., and Denolin, H. Circulatory dynamics in osteitis deformans. *Circulation*, Aug., 1955, *12*, 215–219. (From: Department of Internal Medicine and Department of Cardiology of St. Peter's Hospital, University of Brussels, Brussels, Belgium.)

Circulatory dynamics were studied in 7 cases of Paget's disease. In 1 patient, only the right leg was involved; in another, all bones except those of right arm; in the remaining 5, the disease was generalized.

Increased arterialization of the venous blood was found in the patient who had involvement of only the right leg and the patient who had involvement of all the bones except the right arm by noting that the arteriovenous oxygen difference was considerably lower in an involved rather than an uninvolved extremity.

In the cases of generalized Paget's disease (who also had abnormal arterialization of the venous blood in the limbs) circulatory dynamics were practically normal at rest. It is therefore probable that a high cardiac output at rest is exceptional, being found only in particularly active forms of the disease. This observation is consistent with the finding that, in systemic arteriovenous fistulas (both in man and animals), the cardiac output varies with the importance of the blood flow through the fistula.

These patients were also studied during exercise and it was found that the increase in cardiac output is abnormally high. These findings are similar to those observed in patients suffering from systemic arteriovenous fistulas.—*Myer Sharpe, M.D.*

Waddell, W. W., Jr., McKay, Buchanan M., and Donegan, Charles C., Jr. Possible cast syndrome; report of a case. *J. Bone & Joint Surg.*, June, 1955, *37-A*, 597–601. (From: University of Virginia Hospital and Department of Pediatrics, University of Vir-

ginia School of Medicine, Charlottesville, Va.)

The so-called cast syndrome has been described as a train of events including gastric dilatation, pernicious vomiting, and severe electrolyte disturbance following the application of a body cast. The case here presented differs from others reported in that the symptoms occurred after the cast had been removed and then had been reapplied. The patient survived in spite of levels of electrolyte disturbance which are generally accepted to be lethal.

Roentgenograms of the abdomen showed no gas in the intestinal tract below the stomach. Because of the patient's rapidly deteriorating condition, an exploratory laparotomy was performed under local anesthesia. A large dilated and atonic stomach and duodenum were found with no evidence of mechanical obstruction. After the ligament of Treitz had been divided, the first portion of the jejunum uncoiled somewhat and air began to fill the small bowel. Following the operation, the child began to improve and peristalsis became audible twenty-four hours after surgery. It was the authors' impression that the surgical procedure definitely contributed to the patient's improvement, perhaps by favoring absorption of electrolytes and fluid.

Of 5 reported cases prior to 1950, acute gastric dilatation was present in every instance. The onset of symptoms varied from two days to six weeks after the cast was applied. Of the 5 cases, only 1 patient survived. All the patients were adolescents under the age of twenty-two.

The authors call attention to the possibility that the application of a body cast may be implicated in the initiation of acute gastric dilatation. Death is a possibility unless recognized early and vigorous therapy is instituted.—*Frank Lesko, M.D.*

RADIATION THERAPY

Paterson, Ralston. Why do cancer patients delay? The Gordon Richards Memorial lecture. *Canad. M A J.*, Dec. 15, 1955, *73*, 931–940. (Address: Christie Hospital, Manchester, England.)

The purpose of this discussion is to analyze to what extent public education directed toward decreasing patient delay in seeking treatment for cancer actually achieves any practical degree of success. Initially, the term "early" as used medically is defined as implying a lesion which is limited in extent whether it is of recent origin or remote. It has been well shown that a victim of cancer who has delayed seeking advice for some time may still, in this sense, have an "early lesion." Nevertheless, if the average delay interval is decreased, more patients will be contacted during earlier stages of the disease, and in some tumors, although not all, this is of definite demonstrable value in terms of possible salvage. Patients delaying their medical consultation in the contemporary English scene are classed as those who "did not know" and those who "knew" the nature of their ailment. In the latter group, a certain proportion sought medical attention immediately while another segment postponed such action through fear camouflaged by irrational explanations and excuses. Indeed, the group motivated by fear exhibited a greater average delay than those whose behavior was in the face of ignorance. One reaches the sober conclusion that public education improperly conceived may defeat its own purpose by converting some of the "delay from fear" class. This fear appears to result from misconceptions about the disease. Only one out of three women interviewed thought that cancer was ever cured, and in England at least a sense of shame seems to be linked with the disease. In addition, suffering and death remain outcomes of the disease only too commonly.

The Manchester Experimental Scheme has conducted a study of these problems by subjecting an experimental rural community of 620,000 population to a concentrated publicity campaign over a period of three years. Analysis of breast and cervix cancer cases from the area reveals that roughly one in three of this group were reached by the program and about one third of these were influenced to seek aid. In the case of cancer of the cervix there was some demonstrable reduction in delay periods when compared to precampaign figures. Although public lectures reached fewer people, their effectiveness appeared greater than was true in the case of printed articles. The yield of the campaign is considered quite small in view of the effort and expense required to operate it and important questions remain unanswered, "How many patients influenced by the program have been saved?" and "What is the price of one human life?"

This article contains much thoughtful reasoning and is recommended in its original form as very worthwhile reading.—*James A. Martin, M.D.*

H. M. IMBODEN
Editor
1918-1924